The D. H. Hill Library
North Carolina State
College

October 3 1889

This book was presented
by
R.P. Kolb
TG1
S62
v.2
cop.2

NORTH CAROLINA STATE UNIVERSITY LIBRARIES
S01696918 /

T61
S62
v.2
cop

37682

DA

19Ma

SEP

14De

Librar

This BOOK may be kept out TWO WEEKS ONLY, and is subject to a fine of FIVE CENTS a day thereafter. It is due on the day indicated below:

37682

19May'48 J

SEP 23 1948

Jun'61X

14Dec'61H

Bib Review 2/12 flh
candidate for OCA digitization, per Orion Pozo

Digitized by the Internet Archive
in 2012

http://archive.org/details/reportofinvestig02amer

Society for the
Promotion of Engineering Education

REPORT OF THE INVESTIGATION OF ENGINEERING EDUCATION
1923-1929

WITH REPORT ON SUMMER SCHOOLS
FOR ENGINEERING TEACHERS
1927-1933

ACCOMPANIED BY A SUPPLEMENTAL
REPORT ON TECHNICAL INSTITUTES
1928-1929

VOL. II

With Bibliography and Indexes

Office of the Secretary of the Society
F. L. BISHOP
University of Pittsburgh
PITTSBURGH, PA.

1934

Publication of Reports was initially a responsibility of the Director of Investigations. After his retirement, September 1, 1929, the published Reports and Bulletins were assembled and issued in 1930 as Volume I by the Secretary.

The editorial sponsorship of Volume II was assumed by the Chairman of the Board.

The Publications of the Summer Schools for Engineering Teachers were in charge of the Director of Summer Schools.

LANCASTER PRESS, INC., LANCASTER, PA.

GENERAL CONTENTS OF VOLUME II

Part 1. Continuation of Vol. I (re Engineering Colleges)

Preface lix
Table of Contents lxiv
Final Report of the Director. W. E. WICKENDEN 1041
General Report on Summer Schools. H. P. HAMMOND 1117
Conference of Administrative Officers of Engineering Colleges 1145
1930 Survey 1163
Final Report of the Chairman; a Summary of Results. C. F. SCOTT 1237
Appendix; Report of Development Committee 1922 1274

Publications

  of the Society 1279
  of the Board 1280
Bibliography 1287
Index to Vol. I and Part 1 of Vol. II 1303

Part 2. A Study of Technical Institutes (Non-collegiate)

Contents .... (vi)
Report 1
Index to Technical Institutes 272

To the Reader

The records of the Investigation and its supplemental activities were issued progressively during more than a decade, appearing in the Society's publications and/or its pamphlets. Many of these are assembled in Volumes I and II. All are coördinated by the List of Publications, the Bibliography and the Indexes.

In the two Indexes leading titles are provided with bibliographies of related Bulletins and Reports and with references to the Tables of Contents (in Roman numerals) containing subtitles and lists of tables and diagrams.

Much supplemental material, not included in Volumes I and II, may be located by means of the Bibliography.

37682

MEMBERS OF THE BOARD OF INVESTIGATION AND COORDINATION

Name	Address	Year
Frank Aydelotte	Swarthmore College	1923–27
F. L. Bishop, *Secretary*	University of Pittsburgh	1922–34
H. S. Boardman	University of Maine	1930–31
Mortimer E. Cooley	University of Michigan	1922–28
*J. H. Dunlap	American Society of Civil Engineers	1922–24
H. S. Evans	University of Colorado	1931–32
Dugald C. Jackson	Massachusetts Institute of Technology	1922–34
Dexter S. Kimball	Cornell University	1924–34
O. M. Leland	University of Minnesota	1927–28
*F. W. McNair	Michigan College of Mines	1922–24
George B. Pegram	Columbia University	1926–27
A. A. Potter	Purdue University	1924–25
R. I. Rees	American Tel. & Tel. Co.	1929–30
R. L. Sackett	Pennsylvania State College	1928–34
Charles F. Scott, *Chairman*	Yale University	1922–34
C. E. Seashore	Iowa State University	1923–27
R. A. Seaton	Kansas State College	1932–33
F. E. Turneaure	University of Wisconsin	1924–34
*P. F. Walker	University of Kansas	1923–24

The Staff

W. E. Wickenden, Director of Investigations, 1923–29

H. P. Hammond, Associate Director, 1924–29; Director of Summer Schools, 1927–33

Note: The Advisory Committee and the Staff of the Study of Technical Institutes are given on page opposite the title page of Part 2 of this Volume.

* Deceased.

PREFACE

This volume carries to completion a decade and more of activities conducted by the Society under the auspices of its Board of Investigation and Coordination in an undertaking to "develop, broaden and enrich engineering education."

A Brief, summarizing the Results of the Investigation by the Chairman will be found on page 1237.

An Expanding Program. Initially projected as at least a five-year enterprise, it was at first financed for a period of three years. The program developed and expanded as the undertaking progressed. Supplemental funds were secured as needs were definitely defined.

The initial period of fact-gathering and analysis was followed by the Study of Technical Institutes, by sessions of Summer Schools for Engineering Teachers during seven years, by the Conference of Administrative Officers. The Director made a second visit to Europe in his comparative study of engineering education in this country and abroad. The "1930 Survey" was made. Throughout these undertakings the Society has enjoyed a healthy activity. Interest has been stimulated in educational problems in individual institutions; there has been gratifying development of Sectional meetings at which members from adjacent institutions have discussed their common problems; new Sections have been established, the annual conventions have been accompanied by spirited conferences in Divisions devoted to specific subjects of instruction—all of which is reflected in the reports and discussions which have appeared in the Journal of Engineering Education and elsewhere. The Engineering Societies have become increasingly active in education.

PERSPECTIVE SUMMARY

It is fitting, therefore, at the beginning of the concluding Volume, to present a brief summary of the activities which the Board has initiated and sponsored and to present a brief statement of the publications arising from them.

The Beginning. The inception of the undertaking and the organization of the Board are described in the Foreword and Report of the Chairman at the beginning of Volume I. Additional Preliminary and progress reports are listed in the Bibliography in this Volume, page 1287.

Cooperation with Engineering Colleges. From the very beginning of its work the Board planned "To maintain close contact with engineering schools, enabling them to participate in the investigations and reporting to them from time to time to the end that the developments may be continuous from the initial contact between the colleges and the agencies of the Board." Such participation has been a unique feature of the project. The method of self-investigation of engineering education by engineering educators themselves—a method that was challenged—is discussed by the Director in the section of his report entitled "The significance of the cooperative plan of investigation," page 1042.

Through the *Journal of Engineering Education,* the monthly journal of the Society, data and reports have been promptly furnished to its members. Reprints of reports and papers in two score of pamphlets have been made available. They are listed under the Publications of the Board. The 10 monthly issues are bound annually and form The Proceedings for which a portion of the membership subscribe.

Volumes I and II of the completed report now bring together these records in permanent form indexed for reference. Many of the original reports have been revised and these volumes contain some material which has appeared in pamphlet form but not in the *Journal* (e.g., The Comparative Study of Engineering Education in the United States and in Europe and The Study of Technical Institutes) and also some material that has not previously appeared (e.g., The Final Report of the Director and the Summary Report on Summer Schools). The publications are listed in detail under Publications of the Board.

Volume I presents data of the Fact-gathering stage of the investigation with the reports of Faculty Committees, the Staff, and the Board, based largely on these data. It includes also the comparative study of engineering education in the United States and in Europe.

SUMMARY OF VOLUME II

Volume II contains reports, bibliographies and indexes, which are outlined in the following paragraphs.

The Final Report of the Director, W. E. Wickenden, who retired from the Staff September 1, 1929, was completed in 1933. It has a perspective enriched by experience as president of an engineering college and the new viewpoint which comes with the shift from 1929 prosperity to 1933 depression.

The General Report on Summer Schools, by the Director, Professor Hammond, covers the twelve sessions (1927–1933) which complete the cycle of the principal branches of the engineering curriculum. Many papers from the Summer School sessions have appeared in the *Journal of Engineering Education* and in reprints: Selected Papers of the Summer School. Papers of general interest have been listed in the Bibliography. The pamphlet publications of the Summer School contain about 150 papers and reports which if issued in series of volumes would contain over 1700 pages. Of these pamphlets 19 are reprinted from the Society's *Journal* and the other two from publications of national Engineering Societies.

A Conference of Administrative Officers of Engineering Colleges was held in 1933 under the auspices of the Board for consideration of problems and policies of administrative character. The general report of the Conference is followed by a detailed program in which certain papers are indicated as appearing in the Society's monthly publication. They were issued also in pamphlet form.

The 1930 Survey of the Engineering Colleges was made under President Rees (a member of the Board) with the cooperation of the United States Office of Education. Its object was to secure data concerning engineering colleges primarily for comparison with the data for 1925 which were presented in Reports of June, 1926 and appear in Volume I. The survey also includes general information regarding the progress made in individual institutions during the five-year period. It has a significance which was not anticipated as it presents the conditions in engineering colleges at the beginning of the economic depression.

The Final Report of the Chairman summarizes the Results of The Investigation and Related Activities.

The Appendix contains the Report of the Development Committee, which initiated the Investigation.

The Publications of the Society and of the Board, which have appeared in several serials or independently, are listed for convenient reference.

A Bibliography of articles relative to the activities of the Board which appeared in current publications (1922–1933) indicates the general interest in the problems of engineering education and make this contemporary material available for reference. It contains reference to preliminary and progress reports of the Board and Staff which are not included in the two bound volumes of its report. The Bibliography is selective and does not attempt to include all related articles of the decade.

The Index aims to be more than a list of words and titles. It contains many bibliographies of Bulletins and Reports dealing with particular subjects. Under Curricula, for example, are listed the dozen or more sections dealing with this subject. Reference is given not only to the pages of the text, but also to the pages of the Table of Contents (beginning on page xv) which itemizes subtitles and paragraphs; also to the Tables and Diagrams (beginning on page xliii) which are listed by titles.

This concludes the report of this Investigation of Engineering Education in Engineering Colleges.

TECHNICAL INSTITUTES

The Report of the Study of Technical Institutes (non-collegiate) appears as Part 2 of this Volume II, with independent paging and index.

This supplemental Report was conducted by the Staff of the Board with counsel of an Advisory Committee. It was issued as a pamphlet in 1931 and was given wide distribution both in its complete form and also in a summary report of forty pages.

THE ENGINEERING SOCIETIES

The Board has advocated increasingly active participation of the National Engineering Societies in educational matters. They aided in the Investigation by securing through their committees the opinions of professional engineers concerning educational policies and practices which form the basis of Bulletin Number 13. They, together with the Engineering Foundation, contributed financially to the support of the Investigation and of the Summer Schools.

Concurrently with the activities of the Board the American Society of Mechanical Engineers conducted a survey of the economic status of its members which attracted wide interest. This was an important factor leading to the organization of the Engineers' Council for Professional Development of which the Society for the Promotion of Engineering Education is one of the seven cooperating member-organizations.

This promises active alliance between the professional engineering societies and the engineering colleges. It is a happy realization of an ideal which is expressed in the concluding paragraph of the Report of the Chairman, page 14. "The Board believes that the type of activity it has initiated should be continued. While much may be accomplished by individuals and faculties, engineering societies and industrial leaders, to all of whom engineering education is of vital importance, it is believed that a formal representative general agency, possibly an Engineering Education Foundation, would be of outstanding value in developing continuously engineering education as a potent factor in the progress and stabilization of a civilization based on machinery and power and applied science."

CHARLES F. SCOTT,
Chairman.

CONTRIBUTORS TO FUND FOR SUMMER SCHOOLS FOR ENGINEERING TEACHERS

American Society of Civil Engineers
American Society of Mechanical Engineers
Carnegie Corporation of New York
Carnegie Institute of Technology
Chemical Foundation
Engineering Foundation
Charles W. Gould
General Electric Company
Highway Education Board
Massachusetts Institute of Technology
Portland Cement Association
Purdue University
University of Michigan
University of Minnesota
Western Electric Company
Westinghouse Electric & Manufacturing Company
Yale University

CONTRIBUTORS OF FACILITIES FOR SUMMER SCHOOLS FOR ENGINEERING TEACHERS

Carnegie Institute of Technology
Cornell University
Massachusetts Institute of Technology
The Ohio State University
Purdue University
Stevens Institute of Technology
University of Michigan
University of Minnesota
University of Pittsburgh
University of Wisconsin
Western Electric Company
Westinghouse Electric & Manufacturing Company
Yale University

Note: For Contributors to Other Funds and a preliminary list of Contributors to this Fund see pages 15 and 16.

TABLE OF CONTENTS, VOLUME II

Part 1

The Investigation of Engineering Education (continued from Volume I)

Page

MEMBERS OF BOARD AND STAFF lviii
PREFACE; GENERAL SUMMARY OF ACTIVITIES OF THE BOARD; ELUCIDATION OF PUBLICATIONS, BIBLIOGRAPHY AND INDEXES lix
CONTRIBUTORS TO THE SUMMER SCHOOL lxiii

Final Report of the Director of Investigations, June, 1933. W. E. Wickenden 1041

FOREWORD, SPIRIT AND AIM OF THE UNDERTAKING 1041

I. THE SIGNIFICANCE OF THE COOPERATIVE PLAN OF INVESTIGATION.. 1042
  Engineering Educators Must Look to Themselves for Guidance ... 1042
  How Far May Self-Guidance Be Trusted? 1042
  The Study by C. R. Mann 1043
  Philosophy of Engineering Education 1044
  No Big Transforming Idea Discovered 1045
  This Investigation Sought Middle Ground 1046
  Continuing Influences; the Summer School 1046

II. THE CHANGING SOCIAL PREMISES OF ENGINEERING EDUCATION.... 1048
  a. Focus of Social Interest is Economic Rather than Political .. 1048
  b. Agriculture, its Changing Status 1049
  c. Industrial Technology and Unskilled Labor 1050
  d. Social Utility 1050
  e. Substitution of Machines for Muscular Labor 1051
  f. Stable Population; Age Groups 1052
  g. Scope of Secondary Education 1053
  h. Challenge of Democratic Capitalism 1055

III. THE EXPANDING SCOPE OF THE ENGINEER'S WORK AND TRAINING 1056
  What Does the Engineer Do? 1057
  Licensure for Engineers 1058
  Engineering Will Include Many Sciences 1058
  Engineer as Organizer and Manager 1059
  Preparation for Management 1063
  Science vs. Information and Practice 1067
  Technological *vs.* Economic and Business Base for Curriculum .. 1068
  Post-Graduate Study 1069

IV. ARE THE AIMS AND PROCESS OF ENGINEERING EDUCATION SOUND? 1070
  The Unified Type of Engineering Education 1070
    1. Functional Unity 1071
    2. Individual Adaptation 1072
    3. Motivation 1073

Page
4. Social Orientation 1073
5. Balance of Mental and Motor Activity 1074
6. Cumulative Learning 1074
7. Limited Specialization 1075

V. ENGINEERING SCHOOLS AS SELECTIVE INSTITUTIONS 1077
American Scheme of Technical Education 1077
Forces Shaping Engineering Colleges 1079
1. Individual Welfare as a Dominant Objective 1080
2. Comprehensive vs. Specific Objectives 1083
3. The Movement for Strictly Professional Objectives 1085
Summary 1089

VI. CAN CURRICULA AND TEACHING PROCESS BE MADE MORE EFFECTIVE? 1090
Appraisal of Present Status 1090
The Industrious Plodder *vs.* the Man of Imagination 1092
Spirit of the Secondary School 1093
Four Things Attempted by the Colleges 1094
Text Books and Formal Laboratories 1095
Students and Learners 1096
Engineering Teachers; Qualifications; Research 1097
Selection and Training of Teachers 1099
Suggested Changes in Curriculum and Teaching Processes
1. Freshman Year; Methods of Study 1101
2. Second and Third Years; Supplemental Lectures and Projects 1101
3. Fourth Year; Regular and Honors Groups 1102

VII. THE PROFESSIONAL PHASE OF THE ENGINEER'S EDUCATION 1102
Professional and Other Careers of Graduates 1103
Prolonged Training for Professional Engineers 1103
Present Curriculum a Foundation Stage 1104
Graduate Schools 1105
School and Industry Join in Post-Graduate Training 1106
National Bodies of Engineers 1106
Attributes of Individual Professional Life 1107
Attributes of Group Professional Life 1108
Code of a Profession 1109
Licensure of Engineers 1110
Institution of Civil Engineers 1111
Verein Deutscher Ingenieure 1112
American Professional Societies 1112
Certification of Engineers by the Profession 1114

General Report of the Summer School for Engineering Teachers, 1927–1933. H. P. Hammond 1117

General Summary 1117
Inception of the Summer School 1119
Sessions of the Summer School, 1927–1933 1121
Objectives 1121
Plan 1123
Particular Subjects 1123
Different Institutions 1123
Methods 1123

Page

- Teaching *vs.* Subject Matter 1123
- Informal Features 1123
- General Relationships 1124
- Advanced Studies 1124
- Duration 1124
- Academic Credit 1124

- Program; Content and Arrangement 1124
- Methods of Conducting the Sessions 1126
- Summer School Staffs 1126
- Enrolment and Rank of Attendants 1128
- Financial 1128
- Publications 1129
- Results 1129
- Appendix A. Program of Session on Mechanics 1134
- Appendix B. Program of Session on Mechanical Engineering ... 1137
- Appendix C. Selected Papers of the Summer School 1143

Conference of Administrative Officers of Engineering Colleges, 1933 1145

- Attendance, Program and Publications 1146
- Opening of the Conference. C. F. Scott 1147
- Engineering Education, Status in 1933. H. S. Rogers 1149
- The Outlook for the Future. C. R. Mann 1150
- Budgeting and Finance. O. M. Leland 1150
- Selection and Development of Faculties, Teaching Personnel. J. W. Barker 1151
- Students' Personnel Problems. E. C. Elliott 1152
- Graduate Work, Administration of. D. C. Jackson 1153
- Junior Colleges. George F. Zook 1154
- Engineering Education in the Light of Changed Social and Economic Conditions. W. E. Wickenden 1156
- External Relationship. H. H. Horner 1159
- Accrediting Engineering Colleges. H. P. Hammond 1159
- Actions Taken by the Conference 1160
- Appendix, Program of the Conference, with References to Published Papers 1161

1930 Survey of Engineering Education 1163

- Introductory Statement 1163
- Report of the Survey; Topical Outline 1164
  - Administration; Enrollment and Related Factors 1165
  - Student Selection and Educational Guidance 1170
  - Courses and Curricula 1171
  - Educational Development 1196
  - Graduate Placement and Demand 1212
- Questionnaire of the 1930 Survey 1230

Final Report of the Chairman of the Board, June, 1934. C. F. Scott.. 1237

- FOREWORD—THIS REPORT A BRIEF, SUMMARIZING RESULTS 1237
  - The Beginnings of the Project 1239
- I. PERSONNEL 1240
  - Entering Students 1241
  - Admission of Students 1242
  - Elimination of Students 1242
  - Graduates 1243

Page
The Engineering Graduate in Industry 1244
Teaching Staffs 1245
II. CURRICULA 1246
Evolutionary Trends 1247
Aim of Curricula 1247
III. GRADUATE WORK 1248
IV. THE COOPERATIVE PLAN AND OTHER STUDIES 1249
Economics 1249
Placement Examinations 1251
Research 1251
The Costs of Engineering Education 1252
V. CONCLUSIONS AND RECOMMENDATIONS 1252
Development from Within 1253
Other Recommendations 1254
VI. NATIONAL SYSTEM OF TECHNICAL EDUCATION 1255
VII. OUR ENGINEERING SCHOOLS IN PERSPECTIVE 1256
VIII. SUMMER SCHOOLS FOR ENGINEERING TEACHERS 1260
IX. A STUDY OF TECHNICAL INSTITUTES 1262
Principal Findings and Conclusions 1262
Data *re* Technical Institutes 1267
X. SUMMARY OF THE RESULTS—THE INTANGIBLES 1268
Resume 1268
Engineering Education as a Whole 1269
The Complexity of Engineering Education 1270
Our Technical Education is Unbalanced 1270
Stimulation of Interest in Education and Teaching 1270
A Basis on which to Build 1271
A New Solidarity 1271
The Engineering Societies 1271
Orientation of Engineering 1272
The Project in Perspective 1272
Finale 1273

Appendix: Report of the Development Committee, August, 1922 1274

Publications of the Society and of the Board 1278

Publications of the Society 1279

Publications of the Board 1280
The Investigation of Engineering Education 1280
The Study of Technical Institutes 1281
The Summer School. Selected Papers 1282

Bibliography, 1922–1933. Articles relating to activities of the Board 1287

Index to Vol. I and Part 1 of Vol. II 1303

Part 2

Technical Institutes

STAFF AND ADVISORY COMMITTEE ii

CONTENTS vi

REPORT OF THE STUDY OF TECHNICAL INSTITUTES 1

INDEX TO TECHNICAL INSTITUTES 272

FINAL REPORT OF THE DIRECTOR OF INVESTIGATIONS

WILLIAM E. WICKENDEN [*]

FOREWORD [†]

Upon the completion of the two major projects of investigation (engineering colleges and technical institutes) and the publication of the collated reports, there remains only to consider what inferences and conclusions may be drawn from the experience as a whole. The writer begs the privileges of a commentator, rather than the more hazardous task of drafting a group of final and authoritative conclusions. To attempt the latter rôle would scarcely be in harmony with the spirit of the undertaking. No common plan or formula for engineering education has been in view at any stage, nor has there been any desire to lessen either the freedom of the schools or their capacity for local adaptation. On the contrary, it has been the growing conviction that more than one type of school is needed to round out an adequate national program of technical education on the post-secondary level. The aim has been not so much to pass a verdict on the schools, as to stimulate a continuing process of inquiry, appraisal, experiment and readjustment within the schools themselves. Each was to work out its own destiny with whatever light could be gained from the experience of all and with such guidance as the engineering professions and industries might supply. As the factual data and their more immediate conclusions have already been treated at length, this report deals only with general problems.

---

[*] Director of Investigations, Society for Promotion of Engineering Education, 1923–29; President Case School of Applied Science, 1929– ; President Society for Promotion of Engineering Education, 1933–34.

Note: The author acknowledges with appreciation the constructive suggestions made by members of the Board.

[†] For topical outline, see Contents, page lxiv.

Library
N. C. State College

I. The Significance of the Coöperative Plan of Investigation

The experiences of the investigation have made it clear that engineering educators must look chiefly to themselves for guidance. Practicing engineers and industrial leaders alike have been most cordial in their readiness to draw on their experience for factual data and for specific criticisms and suggestions. The profession, however, has not yet been able to formulate a code of educational qualifications, nor has industry yet been able to express its requirements in other than general terms. Experts in educational theory and method who have worked with teachers of engineering in the summer schools have thrown much light on the processes of teaching and learning, but have not been able to contribute greatly to our problems of objectives, policies and programs.

How far may self-guidance be trusted? The undertaking as a whole is at least a monument to the courage and the solidarity of engineering educators. No major inquiry had previously been attempted as a purely coöperative venture in any division of higher education, and possibly no other group was closely enough organized or disposed by a long experience of working together to attempt it. Only a group of idealists would embark on so intangible an undertaking, and only a group of realists would apply the measuring rod of self-criticism so cordially and impartially. The fact that the effort was a mutual one, made the data-gathering stage a most effective psychological preparation for the findings and conclusions. These came to faculties already in motion and, with neither prejudice nor inertia to overcome, were directly influential in stimulating local betterments. In this sense the undertaking has been richly justified; but what of the broader problems of the adjustment of engineering education as a whole to the changing state of society?

As a matter of social policy it may be questioned whether any activity which touches public welfare so vitally as engineering education does, should be left entirely to its own inner light. Its beginnings, as was natural in a pioneer era, were due to private and local initiative. The Morrill Act of 1862 lent a powerful public impetus and contributed significantly, if somewhat vaguely, to a broader conception of aims. The real patterns, however, were set by a half-dozen schools which achieved an early prominence and became the seed-beds of organizers and teachers. From 1870 to 1900 was a period of rapid and confident expansion based on these patterns. Then followed two decades in which standards advanced, but numerical and material growth were checked, while colleges and courses of other types were experiencing a spectacular expansion.

The sense of arrested progress moved this Society and a group of national engineering societies to propose to the Carnegie Foundation for the Advancement of Teaching that it make an extended investigation of engineering education. This task was entrusted to Dr. Charles R. Mann, and was completed in 1918. Dr. Mann's report reached the colleges in a period of grave unsettlement, due to the world war, when educators were deeply pre-occupied with the problem of salvaging what they could of their programs and organizations from the threatened disruption. The mood of the moment was unfavorable for calm appraisal and for the risks of progressive measures of readjustment. The aftermath of the war, with its tidal wave of returning students descending on decimated faculties, its rehabilitation program and its problems of mental and spiritual readjustment, merely increased the complications. Meanwhile industry and the engineering professions, which at first had been fairly indifferent to the colleges, were growing much more active in both their interest and their criticisms. Unrest was widespread and the leaders in the colleges differed in their estimates, both of their position or of the direction in which progress should be sought. If any progressive movement was to be initiated, it was first necessary to re-animate the spirit of expectancy which had led up to the Mann investigation, and to re-fertilize the seeds which it had sown. Out of this situation came this group of investigations, in which the colleges, industries, professional bodies and public authorities were enlisted.

A sailor without chart or navigating regulations and with no pole star or sun by which to set his course or check his position, must watch his compass, read his log and take numerous soundings. That is precisely what engineering teachers have done, with the help of their collaborators. The facts brought out in these investigations are fairly reassuring to the pilots both as to present position and course. The ships may proceed with renewed confidence, but no guiding principle of a fixed character has been discovered to make navigation a less venturesome process. The specific situation, it seems, is sound but the philosophy of engineering education remains in large measure unwritten.

The shaping of this philosophy is not a problem for the colleges alone, but is largely a responsibility of the engineering profession. The marks of a profession include not only a body of knowledge and an elaborate technique, but also a clear and articulate conception of social function and duty. Training for a profession consists of more than imparting knowledge and skill; in addition the novice must be fitted to this social function and duty. In these respects law, medicine, architecture and the religious ministry hold a more advanced position in the professional scale than does engineering. It is, in fact, this more definite sense of function and duty rather than any superiority in science and technique which invests them with a seeming social and intellectual superiority. In the current conflicts of engineers and architects over the legal right to prepare plans and act as principals in construction projects, it is manifestly not a superior mastery of technique, but rather a more authoritative formulation of social function and responsibility on which architects rely to defend their exclusive claims. Until the engineering profession can define itself in terms of social function and of personal qualifications, as well as specific activities, engineering educators must inevitably set their course by soundings and log readings, rather than by chart, compass and the heavens.

Like art, philosophy is a result rather than a product. No one can make it to order. Time and leisure are indispensable factors in its unfolding. In the development of the older professions there has been abundant time for critical and speculative reflection. The technological revolution, on the contrary, has moved so swiftly that its creators have of necessity been men of action rather than philosophers. Its interpreters have been for the most part professional students—economists, sociologists and historians, with no share in the actual shaping of events. Signs abound, however, that the engineer is beginning to view his work in a more reflective spirit. The revolution he has wrought in social institutions is so overwhelming that he would be less than human did it not rouse his curiosity concerning its workings and significance. That engineers have begun to produce in recent years an interpretive as well as a technical literature, probably marks a significant epoch in the maturing of the profession.

Those who looked to the investigations to disclose some big, transforming idea were due for a measure of disappointment. At the other extreme, the enthusiasts for modern personnel techniques suggested that the engineering colleges recast their programs on the basis of detailed job analyses. Each type of engineer's work was to be dissected into its elements, and a synthesis made by counting the frequency of occurrence of each unit of activity or duty. The precedents for this mode of procedure were mostly concerned with training for highly unitary callings on a moderate level of responsibility. If one decides to prepare himself as a pharmacist, a veterinarian or an office secretary, the hazards of specialization are all accepted before training begins. Furthermore, it is quite practicable to identify in advance the technical situations to be met and the corresponding skills required. The conditions of entrance to engineering and its manifold practices are quite different. High specialization comes fairly late in the process. The job analysis is, of course, fairly indispensable to the training of an industrial technician with a fairly fixed routine. Valuable use was made of studies of usage among foremen, draftsmen, and superintendents in the Study of Technical Institutes. In this realm ''ad-hocness,'' to borrow Flexner's term, seemed eminently fitting, but in the realm of fundamental education for prospective engineers, which is about all an undergraduate college can attempt, distinctly undesirable.

As a matter of common sense, these investigations consistently sought the middle path between philosophy and specific usages on which teachers of engineering, practitioners, industrialists and educationists could find common ground. The coöperation of these groups did not stop with the gathering of factual data, but extended into the stage of interpretation as well. Collective effort of this sort seldom rises to a high doctrinal level and seldom reaches the level of special detail. Whatever may be the immediate and tangible results, the stimulus given to appraisal and experimentation within each of the participating groups and the strengthening of both the habit and the agencies of coöperation are in themselves ample justification of the undertaking.

Many examples of this continuing influence might be cited. None, perhaps better illustrates the continuing results of this collaboration than the Summer School for engineering teachers under the direction of the Board of Investigation and Coordination. While their faith in the soundness of their aims and the effectiveness of their general processes has been confirmed, our teachers have been led to scrutinize their classroom and laboratory practices critically and to seek the counsel of the other groups in hope of betterment. If left to individual initiative alone, or to occasional conferences and conventions, these forces would soon be spent. Half, perhaps, of the gains sought are in the realm of the individual teacher's preparation and work, and half in the realm of pooled experience and coöperative experiment.

In a concerted effort for betterments in teaching, isolation and standardization are both to be avoided as sterilizing influences. Little can be done to improve teaching practices in general; the work must be done in areas of specific interest and application. What is done in one field, needs to be conserved and passed on to men in others. The summer schools have been created and developed with these ends consciously in view. In them, departmental teachers and experts in educational theory and practice have worked side by side with representatives of the engineering professions and industries. No other group of college teachers appears to have developed an equally effective agency for collaboration among similar groups. Engineering teachers and practitioners talk a common language, but special credit is due the educationists, whose offerings on their own ground have seemed too abstract to be of much service to engineers, in that they have been able to make tangible contributions of increasing value when on the ground of the latter. Let us hope that they have shared equally in the gains. "No man," says a French proverb, "has the last word on any subject until he can make it clear to the man in the street."

The Summer School is the logical heir and continuative agency of the investigations. Surveys may point the path to progress, and conventions inspire men to pursue it, but the ultimate gains must be worked out in the class-room and laboratory and on the level of the specific units of instruction. Engineering curricula include at least seventy-five distinct genera of subject matter such as mathematics, economics, mechanics and the like; the typical genus includes three or four species as distinct as algebra, trigonometry, analytics and calculus; and sub-species increase the total number of variants or individual courses, to about one thousand. In the nature of things, it is impossible for any one or two men, or even a Board, to have valid opinions about what to teach and how to teach it under each of these heads, major or minor. It will require almost a generation for the summer school to make the rounds of the principal families alone.

Thus far the Summer School has been a strong fertilizing influence, and one adaptable to a wide range of personnel and of subjects. Some such coöperative laboratory of methods and materials will be needed for a long period, both as a guide to progress and as a symbol of the capacity of engineering teachers for self-direction.

II. The Changing Social Premises of Engineering Education

It is an interesting circumstance that this series of studies had its beginning in the most opulent years of our economic history and its end in a period of unprecedented depression, both due in a considerable degree to technological causes. Society has suddenly become engineer-conscious. It had pictured him as an occasional builder of roads, canals, bridges and fortifications—a silent and independent man who came, surveyed, planned, built and went his way; now it awakens to find him the controlling hand in the whole scheme of economic production. In the drama of civilization the engineer has been called from handling the properties in the wings and back-scene to play a leading part in the center of the stage, and the public is not yet sure whether he is the hero or the villain of the piece.

Circumstances like these forbid us to test our educational programs and processes by narrow conceptions of expediency. They call for a re-examination of the social premises of engineering. Education works with an eye to the future and must take the risks of social forecasting. As the present economic crisis widens and lengthens, it seems increasingly clear that it is no mere pause in the march of society, but a prelude to revolutionary changes. As yet there are no signs on any horizon that science will be dethroned or that society will lose its faith in technology as a means of social progress. It is fairly certain, however, that the engineer of tomorrow will confront new social ideals and new economic standards. While the results of this revolution are not yet clearly indicated, clues may be discovered in the social trends of today.

(*a*) The focus of social interest has become economic rather than political. The Italian and Russian revolutions reveal this change in extreme forms. Our own political order, based on geographical representation, which served an earlier population of farm owners reasonably well, is showing signs of bankruptcy in an age when men's vital interests divide according to occupations, rather than their place of dwelling. The division between political parties has grown indistinct and elections offer a choice of personnel rather than issues. The engineer has never been an important force in politics, except where special circumstances intervened. If functional representation in government should in time be substituted for the present geographical and party system, the engineer's public responsibilities would certainly be greatly increased.

(*b*) Agriculture appears to have reached, for a time, a maximum status in the geographical phase of its development. Until the turn of the century our agricultural history was written in terms of an unparalleled expansion of acreage and of markets. Since that period, agricultural production per capita has diminished, except in war years, while manufacturing has doubled and mineral production increased two and a quarter fold. Farm population has declined by a million or more and the mechanization of agriculture bids fair to accelerate the process. Hope of reversing this trend seems to lie in two possible directions—the substitution of agricultural products and by-products for other raw materials used by industry, and a return to a self-contained farm economy based largely on home production and consumption rather than money crops. The one appears only moderately promising, the other unpromising in itself, but likely to develop widely as an adjunct to industrial employment.

If changes in market demand and in production technique tend to increase the seasonal character of industrial employment and to make the worker's tenure less secure, some such combination of soil and job as Henry Ford has suggested may assume a wide significance. One result would be a considerable decentralizing of industry and of working population. Electrical power and flexible transport have largely removed the older causes for the extreme concentration of industry in great cities.

Industry, commerce and personal service, which in the past have been absorbing fully half of the farm-born population, will apparently receive proportionately larger accessions from this source. The rural states, in recent years, have contributed more largely in proportion to their populations to the enrollments of the engineering colleges than those of a predominantly industrial character. As population flows from farms to business and industry in an even greater tide, this trend will probably continue and possibly increase, adding to the present responsibilities of the engineering colleges for the social and economic reorientation of their students.

(*c*) Recent advances in industrial technology have ended our traditional shortage of unskilled labor and may prove to mark a wholly new phase in our national history. If so, the social philosophy which has dominated our politics, our education and our industry, based on the premises that men are scarce while space and materials are abundant, that society must cherish each individual and develop his powers to the full, that industry must adopt every expedient to save labor but could afford to be prodigal with ore, coal, oil, timber, water, soil and other bounties of nature, may undergo radical revision. The incentives which have shaped the objectives of invention, have supplied engineers with their criteria of economic selection, and have led us to the unparalleled development of the automatic machine and process in the last three decades may lose much of their force. Labor surplus, due to mechanical productivity may swing America nearer to a parallel with western Europe, with its over-crowding of population and shortage of raw materials.

Recognizing that the social benefits of improved technology are spread over the whole population, while the hardships of transitional unemployment fall heavily on individuals, society may with sound justice insist that the economic burden of labor displacements be reckoned in the costs of production. Engineers contemplating the adoption of labor-saving machinery may have to include some form of social indemnity as part of the cost burden on which a profit must be shown.

(*d*) Back of the details of engineering economy looms the more profound issue of social utility, which engineers have never directly faced. In the whole history of research and invention free play to the social consequences has been taken for granted. The doctrine of *laissez-faire* assumes a fair balance between technical and moral progress, but many social philosophers now believe that mastery over material forces has greatly outdistanced the accepted moral and legal controls. Certainly engineers can not assume that the mechanizing process of the past three decades will continue without check, or that sociological factors may be excluded from the analysis of engineering economy in the future, as in the past. Legal rules change slowly and legislation to meet social changes is subject to trial-and-error adjustments. Meanwhile the safety of society seems to require a type of leadership in industry and the technical professions which is highly sensitized on the side of social morals and welfare.

(*e*) The moving force in the industrial revolution of the last century and a half has been the substitution of machines for muscular labor. While this force is far from exhausted, it appears to have entered a realm of diminishing returns. Thus far the substitution of artificial materials for those more or less directly obtained from nature has been a distinctly secondary factor, but one which lately has begun to assume a commanding importance. If pushed to its limits, however, this second factor can hardly be expected to give to industry as a whole as great a stimulus as that which came from mechanical invention, or from steam and electrical power. It may be sufficient, however, to afford a considerable check on any slowing down process. In any case, chemistry and metallurgy are fairly certain to assume greatly increased importance in every realm of engineering.

As a result of this growing interest in synthetic materials, much of the competition of today is between products as well as between business concerns. The constant hazard of every specialized industry is that it may be superseded over night. To offset this hazard, research has been made to serve industry as a weapon of attack and of defense. Large concerns, which can distribute their risks over a wide range of products and which can afford heavy expenditures for research, have sought by these means to strengthen alike their prospects of survival and of profit. The expansion of industrial research creates a wider market for highly trained engineers, and it is apparent that the large and diversified concerns have been thus far more active in recruiting their forces with engineering graduates than the smaller and more specialized ones. It is gratifying to note an increasing scale of research and development activity in the specialized industries, and a rising demand for engineers of advanced training.

(*f*) An era of stable rather than increasing population appears to be at hand. The improved conditions of living of the last century and a half, including the advance of medical and sanitary science, greatly stimulated population growth in the western nations. With the rise of population and the growth of industry the capital values of all natural resources increased prodigiously. America, being in the midst of her developmental growth enjoyed this economic stimulant in highly concentrated form. In the early decades of the last century our population was growing at four times the world rate, and in the late decades at double. The tempo of our agriculture and industry was adjusted to rapidly expanding markets and rising wealth. Just when this growth began to slacken, the world war gave production an immense but temporary impetus, which has complicated the process of readjustment. In the light of the present slackening of population growth, land and natural resources now appear to have been over-capitalized heavily. For a considerable period, the turnover of trade rather than the rise of resource valuations seems likely to be our chief source of accumulation.

Significant changes in age groups are in process, and are already affecting educational doctrine and practice. In 1850 more than half our people were children and youths under 20 and less than one-eleventh were mature adults over 50. The actuarial prospect for 1950 is that barely one-third will be under 20 and practically one-fourth over 50, in short that the ratio of adults over 50 to youths under 20 will have risen four-fold in the century. The sociological consequences are already becoming evident. At the earlier period youth was abundant and maturity scarce, the one at an economic discount and the other at a premium. This condition is now being rapidly reversed. It appears that the age level of life's keenest competition is falling steadily; the decade following adolescence is likely to be less widely available for prolonged training and experimenting with life interests. With the occupational dead-line threatening the middle years, settling down at 30 may entail too great a risk. Young people may have to choose careers earlier and prepare for them more intensively.

If stable population and surplus man-power affect America as they have already affected western Europe, we may see social strata becoming more permanent, the carry-over of wealth from one generation to another assuming greater importance, a sharper cleavage forming in secondary education between preparation for ordinary citizenship and for highly intellectual pursuits, greater concern to fit young people efficiently into the economic system, more of education transferred to a continuation period running parallel to early employment, and more of an effort to create and diffuse a national culture concentrated on the growing leisure of middle and late adulthood. These tendencies seem naturally to confirm the wisdom of an educational program which brings the great body of our young engineers into the normal relationships of the industrial world at the age of 22; they also emphasize the need to provide much more generously than in the past for continuation education for graduates.

(*g*) The scope of secondary education is being greatly extended and its functions widened. Up to the present the high school has taken only an incidental part in the occupational sorting and guiding of youth. In the early future it may have to carry the major part of this responsibility. The states have been steadily advancing the age limits of compulsory school attendance and voluntary attendance beyond these limits has been increasing rapidly. The school has no choice but to hold all its pupils through the early stage of adolescence, and to provide them with the means of finding out their occupational interests and of measuring their capacities against the world's work. The surface of this problem has scarcely been scratched. The number of recognized vocations is said to exceed 30,000 and a majority of those in industry, at least, are so far removed from the elemental experiences of youth that a young person can not easily visualize them or by imagination project himself into them.

The overwhelming magnitude of this task of social and occupational adjustment, involving each year an army of two and a quarter million recruits to the active duties of life, has threatened to overshadow the intellectual functions of the secondary schools, and to dilute the education of young people of intellectual tastes and gifts. Schools, at times, have seemed to resemble department stores where all kinds of merchandise are equally important and the customer is always right. Within the last decade, however, this equalitarian movement has apparently reached its limit. Democratic society is more acutely aware of its dependence on leadership; the man in the street has gained respect for the expert and is less disposed to trust his own collective wisdom. Europe has long provided separately for the education of an intellectual elite, and now the selective movement is gaining ground in America. From this movement the engineering colleges have much to gain. The notion that an engineering course in college is a natural continuation of a vocational type of high school training dies hard, but is dying surely. What the engineering colleges want is a body of students soundly grounded in language, mathematics, science and history, and accustomed to the rigors of solid intellectual work. These standards call for greater segregation of the intellectually minded in the secondary school.

The corollary of an increased segregation of the intellectual phase of secondary education for a selected minority from the exploratory and vocational phases for the vast majority, will be a certain demand for continuative technical training for the less intellectual and more practical pursuits. We may not need more engineering colleges, but we shall certainly need a group of colleges with more exacting standards and more clearly visualized professional aims. As a complement there is unmistakable need for technical institutes and continuation schools in large numbers, with flexible levels of admission, and with programs of work closely related to particular industries and occupations.

(*h*) Democratic capitalism is being challenged by rival social systems in actual operation. The cardinal principles of capitalism are two-fold: (1) the effort to give every individual opportunity to become a producer to the degree of his ability and desire; and (2) the belief that society will need more tomorrow than it produces today and can best entrust its surplus wealth to persons who will not consume it, but use it to augment the means of production. To these ends incentives are offered and due rewards paid. In an era when both the population and the standard of living were rising rapidly, and especially in a setting of virgin resources and undeveloped continent, this principle has been a great stimulus to individual initiative and thrift. The abuses it entailed were vastly outweighed by its social benefits. Russia, faced by a huge task of industrialization and fearing aggression from without, has been unwilling to trust to the slow and uncertain working of private initiative and in its place has substituted state planning and control. Fascist Italy has invoked the same principle, but in less degree. The issue in America is not so much one between capitalism and communism or between the state and the individual as between individualism run wild and a state controlling framework within which individualism can work at its best.

Examples of a socially wasteful unbalance between producing and consuming power have multipled in the post-war period in agriculture, mineral production and manufacturing alike. Machine technology, with its seemingly limitless capacity for increasing production seems greatly to accentuate this loss of equilibrium. The result has been mis-called a dilemma of thrift. The capital and credit structure built up on producing activities may prove to be larger than the buying power of society can sustain in the presence of forces which tend to diminish the volume of employment available. If so, capital may find it difficult to obtain new outlets and industry may find it profitable to distribute a larger proportion of its income in forms that directly augment consumption, that is, as wages and cash dividends. Society, too, may deem it expedient to limit the mechanizing of production or reduce the hours of mechanized labor rather than to have an unemployable proletariat growing on its hands. Engineers, on whose analysis and judgment hang the risks of future investments and plant extensions, will have new social forces with which to reckon. These forces will not only shape their philosophy of industry and wealth, but will enter into their arithmetic of costs, risks, useful life, and earning power.

The social changes sketched above point inevitably to an increasing degree of social control in economic processes. The engineer of a generation hence will almost certainly be guided by economic premises in which broader conceptions of social expediency will prevail than in the more individualistic past. He may not be an employee of the state, but he is likely to work under a wider range of public regulation. He will be then, as he is now, an economic pragmatist, one who accepts the existing order provisionally and works within it, rather than a doctrinaire seeking to undermine it from within or reshape it from without. This attitude is fairly inherent in his professional duty. If, however, the engineer of tomorrow aspires to be a molding influence in society, he will need a more profound and more critical understanding of social forces than that which sufficed for the engineer of a more individualistic era. Social orientation bids fair to take an equal rank with scientific discipline as an essential basis of his training.

III. The Expanding Scope of the Engineer's Work and Training

The beginning of efficiency is a clear definition of aims. None of the engineering colleges, as far as the writer knows, has undertaken to set down its aims in precise terms. Generalities have the advantage of leaving scope for experiment and innovation, but are quite as likely to beg the question. The traditional definitions of engineering are like beacons which give a general direction to education, rather than the range lights of any well defined channel. Closer analysis is essential to any criticism of educational objectives.

Leaving all its details aside, engineering may be regarded as the art of employing the resources of the more exact sciences to solve the practical problems of construction and of industrial production in the most economical manner. The thousand and one things that the engineer does are less significant for our purpose than the way he goes about his work. Most engineering procedure can be broken down into seven characteristic steps:

What Does an Engineer Do?

1. Masters the laws which govern the situation.
2. Gathers the relevant facts and defines the problem concretely.
3. Makes a scientific analysis of the more promising methods of solving the problem.
4. Counts the costs and estimates the returns of the promising solutions.
5. Selects the solution which promises the best ratio of utility to cost.
6. Reduces this solution to a systematic, detailed program of procedure.
7. Executes this program by mobilizing money, men, materials and machinery in a highly coördinated sequence of action.

The engineer has no sharply defined and localized area of work by which he can readily be distinguished, nor do his functions in themselves create a professional caste because of the extreme scope of the field and the large numbers of persons involved. All rationalization of work partakes in some degree of the nature of engineering, but its major tasks lie within three boundaries: (1) technical applications of science, (2) financial and social economy, and (3) coördination of human and mechanical work. Any one of these elements may predominate but all are present in some degree in every engineering situation.

Activities such as are outlined above can never be made the monopoly of an exclusive group. Physicians, lawyers and dentists may pre-empt their respective fields and keep others out, or admit them only in subordinate capacities, by law or by guild regulations. Engineers can do this to only a limited degree because of the extreme scope of the field and the number of people involved. The profession of engineering bids fair to remain a rather vaguely defined nucleus within a large and indefinitely bounded group of technical workers. The licensing of engineers may restrict the use of titles and bestow certain legal privileges, but it can not possibly create a monopoly of the technical applications of science under economic control. The state may require a certain amount and kind of education of men who are licensed as engineers, but should not exclude others from technical employment. Restrictions of this kind belong naturally to the one-level professions where the individual practitioner assumes full responsibility and where public safety is directly involved. Engineering affects public welfare directly wherever safety of construction, sanitation and the economy of public services are involved; otherwise indirectly, through the general working of the economic system. Engineering is a multi-level activity, in which men work in groups of graded responsibility; furthermore, it is much more often concerned with corporate activities than with individual services.

Licensure for engineers has already been adopted by a majority of the states and is undoubtedly here to stay. Wherever the architect is licensed and given definite legal privileges, it is fairly essential to the engineer, who may have occasion to act as principal on any construction project for which plans must have legal approval, that he have a like status and privileges. Licensure will undoubtedly do much to give the engineering profession a more salient character and may potentially raise its educational standards. The definitions and regulations so far enacted, however, accept the *status quo* and have not been of great aid in projecting educational aims and methods into the future. It seems likely that the engineering colleges will construe their purposes more broadly than any licensing regulations or other narrow definitions of professional function would imply.

Looking to the future, the schools of engineering can scarcely limit their concern to the mathematical and physical sciences, to problems of design and construction, and to the specific details of engineering economy. Engineering will include in its tools any and all sciences as they become exact enough to yield economically predictable results. Various aspects of biology, especially bacteriology, are being incorporated into the working tools of engineering now, and technical psychology is fast approaching a similar stage of development. To fit new scientific materials into the scheme of engineering education involves more than a mere addition of conventional courses in zoölogy, physiology, bacteriology, or psychology to the curriculum. The new material needs to be functionalized. A large amount of practical research is still needed to work up bio-technics and psycho-technics into trustworthy tools of engineering. Few of the American schools of engineering seem to have envisaged the problem. A little bacteriology is being taught to sanitary engineers and here and there may be found a topical course in industrial psychology. Almost none of the courses on human relations in industry goes beyond the orientation stage. The Germans have been much more thoroughgoing; the institutes of psycho-technics in the technical universities are in the van of the research movement to bring together the mechanical, physiological and psychological factors in human work within the bounds of a predictable science. Their teaching of the subject grows out of these researches and is genuinely functional.

The outreach of engineers for new and more varied tools is matched by an equal outreach for wider administrative responsibilities. The rise of the engineer as an organizer and manager has been a natural evolution covering the last half century. Early American engineering was largely concerned with the opening up of communications in pioneer regions. The coming of the railroad was its first great impetus. The engineer of that era was one who came, surveyed, planned, built and went his way. He was a pioneer, versatile, resourceful, an opportunist, and a man of highly individualistic qualities. Many traces of this tradition survive in the profession to this day. As the pioneers passed on, their successors built the scattered railroad units into systems. It was a fairly simple thing to locate and build a few miles of railroad, and quite another to keep an intricate network of trunk lines and branches in efficient operation and to plan its logical extension. In consequence the engineer came to be needed as a continuing member of railroad organization. The same was true of mining, of wire communications, of water and power supply and, more recently, of large scale manufacturing. The engineer with a permanent place in industry was still a planning specialist, but he had become a teamworker and his individualism was displaced by a more coöperative philosophy. Still more recently, the concern of industry has advanced from isolated tools and processes to an organic conception of production and service as a whole, in which pure mechanics could not be segregated from financial, legal, marketing and personnel problems, so that the engineer in his planning, is dealing quite as often with money and men, as with materials and machines.

To return to concrete facts, it has been shown that young engineers, in three cases out of four, begin their careers in the realm of technical duties, but that by the age of forty, three out of five are occupied with administrative duties. Most of these latter posts are on the level of functional rather than general management; that is, they have to do with some aspect of research, design, development, purchasing, construction, sales, operation, or plant maintenance, relating to technical products or services. When an engineer rises from the functional plane of management to a post as general executive he usually has to win his way in competition with the ablest men in other functional capacities—lawyers, accountants, sales managers, personnel directors, and the like. In a highly competitive situation, the likelihood of the choice falling upon a young engineer, assuming equal personal qualifications, is largely controlled by the degree of importance which technological factors bear in the entire situation.

In highly technical industries such as mining, metallurgy, transportation, communication, power supply, building construction and large-scale manufacturing, the odds strongly favor the engineer, since it is far easier for him to broaden his knowledge of business through extension courses or less formal means than it is for any non-engineer to master the intricacies of technology.

The engineer's prospects in management are also influenced to a high degree by the distinctive qualities and limitations stamped on him by selection and training. He is likely to be factual, quantitative, analytical and impersonal in his modes of thought; his capacity for judicial thinking, based on conflicting evidence, is usually less well developed; and his intuitive faculties, as a rule, have been so overshadowed by his analytical habits, that he often fails to sense the reactions of ordinary people. He is usually too forthright for adroit politics or suave diplomacy, and when he ventures amid the subtleties of human nature, he risks seeming callow and naïve. The engineer's instinct for safety, his desire to be right in every case, breed a habit of deliberation, of withholding decisions until all available evidence is in. His instinctive concern centers in economy through the elimination of waste, rather than in profit through exploitation. His impersonal mode of thought often makes workers and consumers appear as means to material ends, rather than as personalities having interests, tastes and foibles to be regarded.

The choice of a chief executive for an enterprise is likely to be determined by the nature of the final risks to be borne. If in the last analysis the risk is one of legal restriction, of adverse legislation, or of public regulation or intervention, the situation is favorable to the choice of a lawyer; if it is a question of ability to command capital and credit, a financier is likely to emerge; if the critical issue is one of markets and distribution, one may look for leadership to a sales executive; if success hinges on economies in production, on creating and maintaining an intricate plant, on keeping a complex service in operation against physical odds, or if the constant risk to be faced is that the whole enterprise may be superseded by some new invention or research product, the engineer is likely to have the call; and if the major problem is one of building an effective organization and enlisting the loyalty and co-operation of executives and the working force, the ablest judge and handler of men may be counted on to come to the top.

Viewing industry as a whole, the technical risks appear to be growing in importance with the use of automatic equipment, highly standardized processes and closely interlocked sequences of operation. The risk of supersession has increased greatly as competition has developed chiefly between products rather than concerns, and as industrial research has been widely seized upon both as a competitive weapon and means of defense.

The widespread movement toward scientifically directed management is one of the major forces pushing the engineer into executive rôles. The aim in view is to take the element of guess-work out of not only process and product, but of every possible element of an undertaking. Its effect is to put every step from financing to profit-earning on a planned basis. The Bell telephone system, for example, has reduced guesswork in an impressive degree, in part by research, by setting up units of measurement and standards of performance for all its repeated operations, in part by the integration of development, manufacturing and operating, and in part by the forecasting of its loads, traffic, revenues and expenses. Its policy is deliberately to search out by engineering analysis in advance at what times, in what places and forms, and in what amounts an investment or expenditure may be made to yield the maximum in economies or in improvements of service. It is undoubtedly the most completely engineered undertaking in America, if not in the world, and its consistent prosperity is no mere coincidence.

The significance of this example lies in the fact that it has been achieved under the leadership of engineers of profound scientific qualifications and by normal engineering processes, rather than by any special system or technic of management. Success in taking chance and guesswork out of process and product is usually the key which opens opportunities to the engineer to extend his characteristic procedures to business at large.

Analysis and observation alike point strongly to the conclusion that the engineer has dominant prospects as an executive in certain types of enterprises and only incidental prospects in others. The odds are in his favor wherever effort centers in technical production and service, but much less so where the chief concern is with finance, risk-bearing or marketing. The odds favor him when competition is waged around costs rather than sales, also where the type of labor is mechanical rather than personal, clerical or mercantile. Engineers on occasions have achieved high success in banking, brokerage, insurance and retail merchandising, but in general are disposed to concede priority in these fields to men trained for and in business.

This brings us to the question of what may be done in college to prepare the engineer for management responsibilities. Management,* in its entirety, is an intricate process of coördination, rather than a science. While progress has been made in rationalizing the art of management, most of the ''systems'' which have been set up bear the marks of expediency, and most of the codes of principles which have been formulated are really maxims, rather than verifiable laws.

---

* ''The function of management involves buying of materials at the right time, foreseeing market conditions and deciding how far to go ahead in the storage of supplies; profitable selling of goods at home and in foreign markets and organization of adequate selling agencies, as well as deciding when to sell and at what price; organization of technical processes involving a knowledge of the state of the arts in all countries, good judgment in plant and machinery lay-out and sequence of processes, as well as decision on when the introduction of new inventions will prove profitable; financing of all operations involved in buying, producing and selling, determining the type of credit to be adopted in the enterprise and deciding to whom credit should be extended and under what conditions; and, finally, organization of industry into a well-knit unit, selection of the right persons for the right tasks, development of proper working conditions and coördination of all parts of the manufacturing institution.''—M. W. Alexander, Annual Report of the President of The National Industrial Conference Board, 1926.

In the larger industries, young engineers are not likely to confront problems of large-scale coördination until their late thirties or early forties. By this time the experience and education of the after-college years have had a much greater molding influence than the college course. Biases, interest fixations, and value judgments formed in college, however, often long continue as governing influences. In the smaller industries where the range of technical activities is narrower and where functions are much less divided, the young engineer is likely to be faced by management problems at an earlier age. As a rule, the smaller concerns are less able to give their men special training to supplement that given in college. The young engineer is more largely thrown on his own and greater demands are made on his versatility than on any form of profound knowledge. Some regard is also due to the increasing group of mercantile and financial organizations not engaged in technical production or operation who find it advantageous to employ men who have had a good grounding in science and some orientation to technology, topped off by a fairly extended study of business subjects.

The multiplication of trunk and branch curricula based on technical specialization has gone fully as far as can be justified. Further differentiation in courses for undergraduates is much more likely to proceed on functional lines. The now fairly numerous programs in industrial engineering and engineering administration look in that direction. Both types aim to prepare for management more largely than for technical analysis, design or research, but the former has in view principally the processes of industrial production and the latter management in a less specific sense.

Whether the technology and management of production should be taught in a distinctive curriculum or within the more inclusive province of mechanical engineering appears to be a question of relatively secondary importance. In a number of cases it seems apparent that the separation of industrial engineering into a separate department and course has been dictated by personal or political expediency more largely than by educational policy. The competitive spirit engendered has led in some instances to apparent over-claims for the industrial curriculum. Due weight, however, must be given to the needs of the smaller industrial concerns already alluded to, where the problems of plant and of operation greatly outweigh the development and design of new products. When full allowance is made for these needs the question still remains whether in the long run the time spent in mastering the specific devices of shop management will prove more profitable than the analytical subjects in whole and in part displaced; also, whether the more restricted professional contacts afforded by a special department of industrial engineering will prove more valuable than the more inclusive fellowships of the main body of mechanical engineers.

Whatever one's view on the most expedient scheme of organization and curriculum, it can scarcely be denied that the technology of tools and of production processes has received less than its due in most American engineering colleges. The recent advances in tools, processes and materials, where Americans have led the world, have come from the industries, with almost no help from college laboratories. The shop courses in comparatively few of our engineering colleges have yet risen to the plane of scientific laboratory instruction. More often they have remained as fairly routine and sterile hang-overs from a time when engineering colleges felt an urge to be practical, above all else. The teachers have been craftsmen, more often than engineers of scientific attainments. Critical studies in the physical and economical limitations of tools and researches in the basic phenomena of shop processes have been rare, almost to non-existence in America, but actively pursued in the technical universities of central Europe. Here again, as in the instance of psycho-technics, we see in Europe a reversal of the American point of view. We endeavor to teach the art, but neglect research, while European teaching of production technology is a direct outgrowth of research.

Objective agreement on the value of management subjects in an undergraduate curriculum can not be hoped for in the present state of our knowledge. Engineers of a highly realistic school are openly skeptical; they point out that management is more of an art than a science, that most of its so-called principles are really maxims based on common sense, that expediency outweighs all rules of action in most situations, and that the analysis of management problems is of little worth apart from mature judgment based on experience. To management enthusiasts, these objections are merely signs of a reactionary spirit. Most engineers, they are convinced, will become executives anyway, and might be saved from a good deal of fumbling by being well indoctrinated in college with certain principles of executive action, made familiar with business organization and practices and trained in the analysis of typical business situations or cases. A few extremists would even go so far as to reduce the technological features of the curriculum to a minor element, and replace them with materials taken over directly from the business curriculum.

In the absence of any conclusive evidence, the arguments on both sides are largely presumptive. It is urged on one side that the student can ill afford to divert time from the study of pure and applied science, which he can never learn effectively apart from laboratories and teachers, to a consideration of business principles and practices which he can learn to good advantage only where they are actually employed. In any case what will be of most service to him will be the ability to analyze problems, and for this purpose a profound scientific training is certain to be of more worth than one based largely on intangibles. On the other hand, the position is taken that too complete a pre-occupation with quantitative, factual situations leaves the engineer hard-minded, unimaginative, and insensitive to human factors in a situation; that the teaching of business problems need not be remote from the student's experience if the illustrative materials are well chosen and that the case system brings to the teaching of management values which correspond to those of the laboratory for the sciences.

Each student of the curriculum has his own scale of values, his own estimate of the weight to be given to what students and their prospective employers want or think they want, and his own ideas as to what may safely be left to an earlier or later stage of after-college education. Furthermore, there is no one correct solution, and there is room for more than one kind of school and more than one type of curriculum. The investigation has not settled the issue. The genius of engineering lies in a method rather than in any group of specific technics. This method, as already outlined, rests on a solid mastery of those sciences which lead to predictable results and upon a broad understanding of the principles of financial and social economy. To these must be added an adequate mastery of written and spoken English. Three subject groups, namely, the more exact sciences in both their pure and their technological aspects, the foundations of economy, and the English language, are the indispensable framework of the curriculum. All other questions of content—how much and what kind of practical technology, business practice and industrial management to teach, what electives to offer in collateral sciences and humanistic branches, and the like—are in comparison secondary and incidental.

Can any far-seeing student of engineering afford to slight the living and growing sciences for scraps of information or details of practice that may be obsolete before he is out of college, or exchange a solid understanding of economic forces and institutions for the dubious privilege of toying with the problems which engage executives twenty-five years his senior? In reality, however, the issue is not so simple as academic minds sometimes picture it, for long experience has made it perfectly plain that principles are best taught to future engineers in connection with their application and that a fairly even balance is desirable between the mental and motor forms of learning. Realism should suggest, too, that not all students are as far-seeing or as philosophic in their interests as the above ideal would imply. Motivation springs from the actual ideals and purposes of the student rather than those his seniors believe he ought to pursue.

Are we not tempted at times to take the curriculum too seriously, to look upon it too much as if it were a precise chemical formula? What, after all, is the witness of experience? Equally good men have come from colleges with one curriculum and with seventeen, from colleges which require four years of shop work and those which teach none, and from coöperative courses and those on a full-time basis. Engineer-executives appear among men who have been profoundly trained in science, it would seem, quite as often and as early as among those who specialized in college in engineering administration. If we accept the quality of a man's thinking and his effectiveness in putting thought into action, as the real tests of his education, we would all agree that these qualities are more often measures of the effectiveness of his teachers than of the worth of the things taught.

There is actually no issue involving the pre-technical curriculum of the first two years, where the predominance of science is unassailable. The real choice is between a technological base with an economic orientation and an economic and business base with a technological orientation in the last two years. Both types of education are worth while, and both are appropriate to an engineering school, but in most institutions the former is unmistakably the norm of engineering education and the latter an accessory. The teaching of engineering administration to undergraduates in most instances might well be limited to a year's survey course for seniors and to electives in accounting, statistics, labor management and similar business subjects. The survey course in engineering administration would present in outline the principles of business organization, the major business functions such as finance, purchasing, selling, risk-bearing, fiscal control and personnel management, the elements of the law of contracts, copyrights and patents, the principles of economic selection on the basis of first costs, present worth, annual costs and depreciation, and certain phases of psychology which bear on the direction and motivation of men. Lecturers from the business world should be invited to supplement a faculty teacher and problems should be chosen largely from the realm of the student's own experience. In general, it is desirable that the social and economic aspects of engineering should be taught in connection with the technical courses themselves.

However, if we try to ground the student engineer in the more exact sciences, to upgrade his literacy, to give him an understanding of economic forces and economy, teach him an engineer's habits of analysis, introduce him to some major branch of technology, acquaint him with the principles of industrial organization and management, and adjust him to the ever-widening functions of his profession, all in an undergraduate period of four years, we are doomed to hopeless superficiality.

The most serious deficiency in engineering education is not so much in matter taught or omitted in college, as in allowing the orderly process of education to stop, where it so often does, at graduation. To require all engineering students to remain five or six years in college would be an arbitrary solution, but an artificially simple one. This proposal seems too often to spring from a vague idealism which ignores the law of diminishing returns in the experience of the average student. It would be well, however, for at least one-fifth and possibly one-quarter of those who now receive the bachelor's degree to remain or to return after a year or two of experience for a period of full-time post-graduate study. Engineering schools in industrial centers would do well to provide graduate courses at hours convenient for part-time students, particularly where coöperative arrangements can be made with local employing concerns. The programs for graduates could include a year's complementary program in engineering administration for men who had completed one of the major technical programs as undergraduates.

Formal programs given by colleges, however admirable in themselves, solve only a part, perhaps the lesser part of the problem. It seems evident that the most urgent educational task now before the engineering profession is to create and direct an effective program of continuation education for the first five years after graduation from college, using the existing colleges as centers wherever possible, integrating into a larger program the many admirable training courses now maintained by employers, recognizing the more meritorious of the present correspondence and extension courses, adding to these as needed, and leading up to professional certification by the national engineering societies.

IV. Are the Aims and Process of Engineering Education Sound?

The exponents of education in applied science, while never precisely on the defensive, were for a long period seeking vindication in a world dominated by partisans of the traditional humanistic disciplines. Among the latter ''technical'' was often construed as the antithesis of ''cultural'' and the engineer consigned to a place among the philistines. These critics granted that technical education had its place, but contended that this place was either in the realm of specific vocational training or in a professional school which should follow three or four years of study in a college of liberal arts. Educational leaders of the older school were apparently confirmed in this attitude as one and another of the long-established schools of law, medicine and divinity came to terms with the arts college and recognized it as an exclusive avenue of entrance. In the light of these precedents a few engineering colleges made brave efforts to establish themselves as graduate professional schools, while others were soundly criticized for holding to their unified undergraduate curricula.

The case for a unified type of engineering curriculum has been elaborated in the Preliminary Report of the Board of Investigation and Coördination and need not be restated. It appears that the movement for a sharp segregation of cultural and technical stages has about run its course. A new generation of educational leaders has arisen which tests the validity of educational procedures by an appeal to psychology, sociology and economics, rather than to the lore of the ancients. In seeking a unifying and orienting principle which can be applied widely, this new school of thinkers is turning more and more to a functional conception of education rather than an instrumental one. The central idea is to equip the student to cope with a characteristic group of life situations, rather than to train the mind in some abstract sense. The long and costly sequence of college, professional school and apprenticeship is increasingly called into question on grounds of social economy. An increasing group of institutions is setting the terminal point for general education at the end of the second college year; further effort is expected to have the highly directed qualities of the graduate school. While the transition is less abrupt in the unified engineering curriculum, the two plans are highly consistent in principle.

It is therefore timely for engineering educators to cease defending and to begin commending the underlying conception and plan for their work to the educational world. Advocacy of a unified functional undergraduate program as a norm need not close the door to the purely professional graduate school. The weight of world experience, however, favors the entrance of prospective engineers to their studies in applied science at an age level between 16 and 19. If a more selective and extended scheme of secondary education can be established in the United States by telescoping the present junior college into the secondary school, and so reach the levels of attainment which prevail in Europe at 18 or 19, so much the better, but until that time the present age level, rather than any fixed academic level, will probably continue to mark the threshold of the engineering college.

Certain characteristics of unified education which the more liberal engineering curricula exemplify, may be worth pointing out to educators at large:

1. **Functional Unity.**—Education is concerned with the individual as a type of person and with his fitness to cope with life situations. The one aim is ''cultural,'' the other ''functional.'' Traditionally the two aims have been thought of as divergent; in the modern conception they are complementary. Indeed, the recognition of their complementary character is a recovery in part of the philosophy of the old-time universities, which before the modern age of science was a foremost feature of attraction for students. Actually, it is difficult if not impossible to dissociate them.

In examining recently the catalog of a college of liberal arts which in the past has been jealous of the ''purity'' of its offerings, a striking example of renewed acceptance of this principle was noted, in that each departmental announcement was prefaced with a detailed statement of the functional values of its courses in various callings and activities. The classical and mathematical studies of the early American college had this type of functional value for the ministers, lawyers, and teachers of that period. The engineering curriculum of a liberal type, with all its elements—scientific, humanistic and technological—closely selected and highly integrated, has this value for the modern industrial scientist in even higher degree. Whether this is good or bad education depends on one's point of view. If one believes that scattering one's interests leads to breadth, if one believes that only disinterested studies have cultural values, from his viewpoint it is at least a limited, if not a faulty program. If one believes in concentration, backed by an adequate mastery of intellectual tools and a considerable social orientation, it is good education.

2. **Individual Adaptation.**—Liberal education seeks to give the student a sense of balance and direction, and regards his personal development as an end in itself, whatever his powers or interests. In principle, its range of individual adaptation is unlimited. A professional discipline makes exacting, almost procustean demands for conformity to type, hence presupposes a high degree of selection in advance. The engineering colleges have gravitated to a median position; the selection of students, while not conforming to precise specifications, does accord with positive types of interest and aptitude and the range of individual adaptation afforded by the choice of curricula and the frequent subordinate options, while more restricted than in the arts college, is actually fairly wide. The general trend of educational thought in past years has regarded the highly elastic program of the arts college as a norm, and the semi-rigid program in engineering as a deviate, needing to be justified. This attitude bids fair to reverse itself. As the age levels of intense competition move downward, there is a rising demand that as adolescence passes,

education shall become purposeful. The graduate in arts, in many instances, has merely postponed the hazards of choice and the pains of adjusting himself to the world of work until after graduation, with a long period of unsettlement as the result. The engineering graduate has already made the greater part of this adjustment while in college.

3. Motivation.—The spirit of application which prevails in the engineering colleges is widely recognized and often envied by educators in other fields. The impelling motives are easily recognized—the student's immediate interest in the materials of learning and the career interests in the making, reinforced by a disciplinary tradition of long standing. The disciplinary urge is doubtless overworked by some engineering teachers, but is more often over-emphasized by outsiders. Some of the rarer flowers of disinterested culture, such as esthetic sensitiveness and philosophic criticism, may seldom thrive in this soil, but a sturdy intellectual curiosity appears to be quite as common among engineering students as in other undergraduate groups.

4. Social Orientation.—Early engineering curricula borrowed freely from the traditional humanities out of the conventional thought of the day. The scientific and technical materials of instruction available were comparatively meager. As the sciences and technics developed the humanities gradually fell to a minimal level and the program became badly congested in the attempt to provide a fairly complete and practical technical training in a four-year course. In time the futility of all attempts to keep the training in practical technology abreast of the times was recognized by teachers and employers alike; the scientific foundations were given an increasing share of time and the burden of practical training pushed over into the after-college apprenticeship. Meanwhile, there had been a rising appreciation of the molding influence which applied science was exercising in the whole structure of civilization. Engineers found themselves thrust into positions of executive responsibility which made heavy demands on their powers of expression, their economic understanding and their insights into human nature and social institutions. Two decades ago the ebb tide of the humanities in the engineering curriculum began to turn. It might be observed, however, that the materials added or restored were being selected with a view to their functional value to the engineer rather than for any abstract cultural values. English was increased on the side of expository writing and speech. History and economics came to be regarded as essential to an engineer's social orientation and to be taught accordingly. Psychology, sociology, and political science were brought within the range of electives. Courses and curricula were set up which gave greater attention to the human factors in industrial production. Meanwhile the teaching of the technological subjects has been marked by a distinctly greater emphasis on economic factors. While this liberalizing movement has not yet reached its full development in all the colleges, it has served to establish firmly the principle that studies which aim at the social orientation of the engineer are an integral and indispensable part of his training. Engineering educators are increasingly convinced that this orientation can best be supplied within the engineering curriculum proper, rather than in some pre-engineering program under other auspices.

5. Balance of Mental and Motor Activity.—Learning involves two sorts of processes, one based on study, analysis and reflection, and the other on actual doing. Liberal education, in its traditional forms, leans heavily to the former; vocational education depends chiefly on the latter; but the modern engineering curriculum maintains a fairly striking balance between the two modes of learning. In the best planned programs the two reinforce each other admirably. The element of variety so provided is undoubtedly one of the strongest reasons why the engineering student is willing to do a larger volume of work than other undergraduates.

6. Cumulative Learning.—A minimum of subject matter is covered but once in the engineering curriculum, then left to be forgotten. The more elementary mathematics repeats itself constantly in the higher branches; mathematics and physical science repeat themselves in the basic technology; technological theory repeats itself in the courses in application and design; and in this way the entire learning process provides a high degree of internal reinforcement. In the light of modern ideas of repeated learning and of retention, these cumulative processes are invaluable.

7. Limited Specialization.—The problem of specialization in the engineering curriculum has been much discussed. The existing programs are the product of a long series of trial-and-error adjustments. They reflect a century of compromise between a fairly consistent educational theory and innumerable practical issues—the student's preparation, the definiteness of his purpose, the time and money at his disposal, the balance of his scientific and practical interests, his non-bookishness, his preference for concrete types of achievement, his inductive habits of learning; the natural desires of teachers to push on to the limits of their subjects, their belief in the superior values of scholarly achievement, their distrust of formal ''educationism,'' their predilection for content rather than process in teaching, their ambitions to magnify their special fields of responsibility; the criticisms and desires of employers; the recommendations, often vague and often detailed, of engineers; and the reactions of graduates to their training in the light of later experience.

Much of the present specialization would disappear from the engineering courses proper if we had more schools and colleges devoted to specific industries, such as textile manufacturing, printing and engraving, paper technology and the like, which are often loosely classified under engineering. In the opinion of many, the result of this loose inclusiveness has been unfortunate. For one thing, it has obscured the need for a distinctive training for operating executives in the highly specialized industries, for which the more generalized engineering courses have not proved an effectual source of recruitment. Not all, perhaps not many of the schools for specific industries need to be four-year colleges, but a strong standardizing influence has been at work tending to draw every course which bore the name engineering into the four-year group. The general pattern of the engineering course, with its first two years largely pre-technical and its third year largely given over to generalized technology, is not well adapted to this type of training. On the other hand, the inclusion among engineering courses intended to provide a professional grounding of courses devoted intensively to specific techniques leads to confusion of aims and standards, lessens the homogeneity of personnel and dilutes the professional atmosphere.

Any educational process which exhibits the seven qualities outlined above rests on a firm foundation of individual and social usefulness. A series of tests of general educational achievement recently given to senior students in Pennsylvania colleges have shown in a striking degree that in so far as this is a measurable quantity engineers are able to hold their own with all other groups of undergraduates. The assumption that the requisite scientific grounding and social orientation can best be gained in a separate period of academic studies is quite at variance with the evidence. An impressive group of individual cases and body of opinion can be cited on both sides of this question, but a strong presumption remains that the proposals for such a segregation of foundation and technical studies arise from the desire of the arts colleges to gain added protection for their traditional interests. A detached and disinterested culture is indispensable in certain callings and, in the hands of limited groups, of incalculable worth to society. To set up this ideal as a condition of entrance to all professions would be sheer folly. When highly cultivated men choose to become engineers, so much the better, but what the technical professions require is not so much a fixed level of personal graces as a thorough scientific grounding and mastery of technique, interwoven as warp and woof, with sound social and economic understanding.

The usefulness of the engineer depends on his ability to accept the existing social order tentatively and to work within it, whether it be a capitalistic democracy, a fascist system of state control, or a proletarian dictatorship. The engineer is of necessity a social pragmatist who obeys the apostolic injunction, "Test all things; hold fast to that which is good."

Like other men, the engineer needs to formulate some scale of social values in order to judge what is good. If he rejects the existing order as evil, he destroys his usefulness; if he accepts it as sacrosanct and final, he reduces himself to a mere servant of vested interests. Social radicals are wont to criticize engineers on the score of social complacency and to regard them as victims of an uncritical or illiberal education. Even if this were true, it would not invalidate the principle of a unified, functional education. The changing social premises of engineering are reviewed in another section of this report. Obviously social factors will have increasing weight in all engineering decisions and in all phases of engineering education, but it is equally obvious that the social orientation of the engineer is at best an integral part of his professional training rather than an academic preliminary.

V. Engineering Schools as Selective Institutions

On the evidence of these studies, the typical American college of engineering may be judged to be a relatively efficient institution. The graduates function effectively in their intended careers; comparatively few pass into pursuits unrelated to their training; many of these insist on the superior values of an engineering education; and few of their number would clearly have profited more from some other type of college training. Apparently no other group of undergraduate colleges have visualized their aims more clearly, chosen their materials with greater discrimination, or maintained their standards more consistently. While the end products, the graduates, represent a minimum of educational waste, the same is scarcely true of the by-products, or non-graduates, especially those eliminated early in the course of study. The ratio of graduations to admissions in many institutions is admittedly low. Whatever this may signify for college standards in particular, in the larger scale of social values it points to a serious deficiency in educational guidance.

If the colleges, as a group apart, are efficient, the same can not be said of the American scheme of technical education as a whole. Lack of clear and critical thinking on the diverse aims, types of schools and character of programs which should have their place in any adequate national system exists on every hand. Lack of broad social planning is painfully evident, when one compares the United States with any part of northern or central Europe. Planning has been nobody's business. The federal and state governments, professional and industrial organizations, both national and local, and educational bodies alike have been indifferent. Legislative action, such as the Morrill Act in aid of the land-grant colleges and the Smith-Hughes Act in aid of vocational education, has been piece-meal in aim and effect.

Free initiative, which might be expected to result in a wide variety of schools with marked individuality, has paradoxically produced quite the opposite result. A few institutions, all tending to grow more alike, gained an early prestige and were widely imitated. Because these schools were ranked as colleges, every technical school feels the urge to become a college. The college degree became first a social hall-mark, then a tangible asset in the eyes of employers, and because no other form of educational credentials received recognition, every technical student wanted a degree. Welfare institutions, with the aim of serving the educationally unadjusted young man, established educational departments with technical classes; soon they were imitating the conventional engineering programs and granting degrees with a generous hand.

From the viewpoint of social economy, the multiplication of engineering colleges to the nearly complete neglect of other forms of technical education is most unfortunate, not so much because technical education of this one type is being seriously overdone as yet or because it threatens a dilution of standards—although this is a real danger—as because technical education is being so widely neglected at other levels and in other directions. Colleges are thronged by thousands who should be cared for elsewhere and tens of thousands who should be in training for efficient service as the technicians and supervisors of industry are left unprovided for. Industries which have not analyzed their personnel needs with discrimination are getting a one-sided recruitment, one that is fairly adequate on the staff or planning side of organization but one wholly inadequate on the line or producing side. The dominance of one educational pattern, under the prestige-bearing name of ''engineering,'' leads educators and industries alike to confuse the fairly general grounding in applied science and economics which is appropriate for the engineer with the much more specialized training in the technology of particular industries, such as textile manufacturing, printing, building construction, sugar-making and flour milling. The two types of education are both technical, but otherwise so different that placing them in the same unit of educational organization leads to almost certain confusion of aims and compromise of standards.

Certain forces now at work shaping the engineering colleges are revealed in three fairly distinct movements, two of them somewhat parallel and the third opposed, which seem to warrant special attention. One may be called the individual-welfare movement, and the second the comprehensive-function movement; while the opposed movement is one for more strict professional standards.

The rising demand for college advantages is in large part frankly social rather than intellectual in aim. Much of it springs from a desire to assimilate young persons to a mode of life quite unlike that in which they were born and reared. In the younger states, many of which have telescoped the entire span of social evolution from sod-breaking to a system of complex economic interchanges into fifty years or less, this making over of each new generation to a new pattern of life has become a social passion. The names and forms of institutions which in older societies are dedicated wholly to intellectual services have been seized upon eagerly for this work of assimilation, most worth-while in itself, but with a result highly confusing to educational aims and standards. American experience has not yet demonstrated whether it is possible or not to reconcile in one and the same institution such diverse functions as the disinterested pursuit of learning and research, rigorous training for intellectual professions, practical training for many vocations, the social making over of conglomerate populations and the broadcasting of practical aids to the farmer, the mechanic and the housewife. The experiment is being tried in scores of publicly supported institutions.

While this experiment deserves sympathetic consideration, it is not yet certain that it will lead to a permanent norm. With increasing maturity of social organizations these functions are likely to become more clearly segregated, as is already the case in the older sections of the United States and in Europe. For the present, at least, the existence of both specific-function and multiple-function institutions appears not only desirable but inevitable. The same is true of an individual-welfare emphasis and a professional-selection emphasis within the engineering schools proper.

1. Individual Welfare as a Dominant Objective.—No American college for undergraduates is wholly free from the function of social assimilation in the sense that the European university is free. Our graduate professional schools have won a partial freedom with difficulty and hold it precariously. Standards of selectivity in engineering colleges are bound to reflect regional differences. For some institutions in populous centers, where educational opportunities exist in the widest variety, rigidly selective intellectual standards are fairly obligatory; while others in new and thinly populated areas are fairly bound to keep an open door to talents without too strict insistence on personal, or even intellectual, preparation. The divergence between privately and publicly supported institutions in this respect has been less than might be expected. A broad social policy dictates that technical education be kept widely accessible, both socially and geographically, on terms of admission which local systems of secondary education can reasonably bear. The nation-wide chain of land-grant colleges is an ample guarantee of this policy.

Whether the claims of individual welfare justify the present movement to establish engineering colleges with extremely slender capital and material resources in city Y. M. C. A.'s is a more complex question. The sponsors of the movement point out that the unadjusted young man of fifty years ago had a sixth-grade education, that twenty-five years ago he had an eighth-grade education, and that today he is a high school graduate. The point is also made that the older engineering colleges in the larger industrial centers do not provide for all the young men who wish to prepare for industrial careers and that local industries are either willing or can be induced to accept an additional recruitment from a local institution actuated primarily by motives of individual service. The right of every young man to whatever training will help him to get on in the world is tacitly assumed, irrespective of the possible results of over-crowding the technical callings and dilution of professional standards. If the cost of this education can be kept within the student's ability to pay, or his ability to earn under a part-time employment plan, it is held to be justified as a personal service, irrespective of its effect on educational standards. To an uncritical public a college degree is a college degree. As long as no other credentials receive the same social and economic recognition, who can object to every young man wanting one?

It is impossible, of course, to expect the advocates of this welfare ideal and the advocates of higher educational and professional standards to see eye to eye. The evidence at hand indicates that engineering callings at the several educational levels are no more over-crowded than other callings at the same levels. The most reliable figures indicate that graduate engineers are as well compensated, on the average, as physicians with their longer and more expensive training, or as lawyers, architects and dentists. There is little decline in an engineer's earning power during the later years of his active life. In industry, at least, the engineer appears to be in much greater demand than men with college training of more general types and to enjoy correspondingly better prospects. There is little or no actuarial evidence of serious over-recruitment from the present educational sources. The number of engineers of fair professional qualifications in the United States is not accurately known. Apparently it exceeds 100,000 and is well within 150,000. To maintain this group against losses by death, retirement and withdrawal calls for an accession rate of about 3.5 per cent and to expand it in pace with the average trend of industrial activity an additional 1.5 to 2 per cent per annum, or approximately 5,000 to 7,500 novices each year. In addition there are even greater numbers of industrial supervisory positions not commonly classed as professional and not yet largely recruited from the colleges. The engineering colleges are graduating about 11,000 men each year; one sixth of this number, in the light of past experience, may be expected to pass sooner or later into wholly non-engineering pursuits; so that when allowance for direct professional recruitment has been made a margin of only 2,000 to 4,000 remains for the fairly limitless semi-engineering fields for which the demand in normal times has been rising more rapidly than the immediate supply.

All in all there seems to be little ground for a policy of excluding from the field of technical education any agency or institution that is equipped to do its work honestly and well. If the welfare institutions are to be criticized it is not for entering the field of technical education but rather for avoiding its more neglected areas by closely imitating the widely developed and recognized programs. If protection of standards is needed, the accrediting of engineering schools by their own organization and the national professional societies will probably prove to be much more effective than accrediting by educational bodies of a more general character.

The junior college offers itself as a solution of two problems which touch on engineering education, that of a more advanced goal for the secondary school and that of making some degree of higher education accessible to larger groups in the population. In Europe the program of secondary education which serves as a fairly universal foundation for higher professional training covers much the same ground as our present high school and that proposed for the junior college. It is a more highly integrated program and, as a rule, is done much more thoroughly. If and when similar goals can be reached by moderately selected groups at the age of 18 or 19 in

America, as in Europe, the advantages to the higher schools of engineering will be pronounced. Merely to prolong our present non-selective type of secondary education to the age of 20 or 21 would be quite another matter. To relinquish any part of the present engineering curriculum to junior institutions of this type would result in a fairly certain loss of time or of effectiveness. Many of the stronger junior colleges prepare students to enter the engineering schools with advanced standing, but the latter set and maintain the standards. From the view-point of local convenience, this plan has much to commend it, since it tends to relieve the overcrowding of large institutions and lessens somewhat local pressure which might lead to an over-multiplication of colleges attempting full programs.

2. Comprehensive versus Specific Objectives.—Good examples of the ultra-comprehensive type of technical education are afforded by many of the colleges of agriculture, which seek to cover the whole range of problems, scientific, technical, economic, sociological and political, which affect rural life. Hence arises a wide range of educational means and methods, including curricula of varying lengths and levels, research, practical experimentation, educational extension in all its forms, advisory service, control of animal and plant diseases and the like. Agricultural education has shown a tendency to absorb into its comprehensive organization all other branches of learning with which it develops affinities; accordingly we find included agricultural economists and sociologists, soil chemists and physicists, specialists in farm management and accounts and of late agricultural engineers. Granting that the results of this policy of educational inclusiveness as developed in so individualistic a field as agriculture may be admirable, is a similar policy and organization desirable in the more highly professional field of engineering education? Should the engineering schools gradually be transformed into comprehensive colleges of industry and public works, with teaching, research and extension activities covering the whole range of their technical, economic and personnel problems?

If we may judge from agricultural education, the almost certain result of such a policy would be the virtual disappearance from engineering education of its professional qualities and affiliations. This we would rightly deplore. The experience of more mature countries abroad confirms the need for engineering education of a variety of types and levels, but indicates that each type succeeds best in schools devoted to fairly specific aims. Comprehensive technical schools, comparable to our agricultural colleges, have succeeded only in Great Britain, where schools of this character are of highly local character and have very limited contacts with the university system. The evidence indicates that we can best be served by an articulated scheme of technical education, rather than by a loosely comprehensive scheme on the one hand, or a single inflexible type on the other. This view favors a diversity of schools, with clearly visualized aims and mutually selective standards of admission. There is little hope of the engineering colleges emerging from compromise of standards and confusion of aims if they attempt to occupy the post-secondary field of technical education on an all inclusive scale.

The distinction in aims and programs between the engineering college and the technical institute has been set forth in detail in a separate report. A further distinction deserves to be emphasized, that between specialized training in particular industrial processes and broadly functional preparation for engineering. An example may make the distinction clearer. A man trained in the design of textile machinery and in the lay-out and equipment of textile manufacturing plants may properly be called a textile engineer, but his training and functions are quite different from those of a man skilled in the manufacture of yarn and fabrics. The one needs a broad grounding in pure and applied science and only a modicum of experience as an operative; the other needs only selected elements of scientific training but an extended training and experience in the detailed operations of the craft. The latter is not properly called an engineer and his training properly belongs to a school or college devoted to specific industries rather than a college of engineering. Where both types of training are offered in the same institution, they should be under separate divisions of organization. Schools of industries are greatly needed in the United States, but mostly of the technical institute type. It might be an excellent thing if no additional colleges of engineering were to be established for a decade or two and all new undertakings were directed into these less occupied fields.

3. The Movement for Strictly Professional Objectives.—The norm in American engineering education has remained for nearly a century a unified and highly functional course of studies at the undergraduate college level. The great majority of the schools have held consistently to this pattern. Among a few there has been not so much a movement as a drift toward a more comprehensive school of industry. Another small group of institutions have moved in the opposite direction with the aim of becoming highly professional in character. The prevailing confusion of ideas is reflected in a corresponding confusion of terms. If usage were uniform and explicit many, perhaps most, of our controversies would never occur. Add to the great elasticity of the term ''engineering'' itself such loose educational classifications as ''vocational,'' ''professional,'' ''functional,'' ''technical,'' ''industrial'' and the like, and the door is open to endless disagreements. Without seeking to set up a special glossary, it seems desirable to make some of the usages hereafter employed as explicit as possible.

Engineering, in its more extended sense, consists in applying the resources of scientific technique and economic selection to construction, industrial production and a wide range of technical services. So conceived it is one of the broader sectors of intellectual activity, comparable with finance, education, the fine arts, the healing arts, military defense, religious ministry and social betterment. Each of these sectors has its characteristic intellectual content, its criteria of value, and its code of responsibility, as well as its distinctive problems and techniques. Each includes a varied and graded group of individual callings. Those which are performed on a high intellectual level, with an intricate technique, and with a high degree of responsibility both to client and to society, may properly be called professions. Training based largely on specific problems and techniques, but with only incidental regard to scientific foundations and social backgrounds is generally termed ''vocational.'' ''Professional'' education also deals with the problems and techniques of a specific occupation, but does so more broadly, on a high intellectual level, and against the full background of intellectual content and social philosophy. There is a more general type of education which deals with the intellectual content, basic skills and social values of a group of related occupations, without going deeply into the problems and techniques of any one realm of individual specialization. For this type of education the term ''functional'' is more appropriate than the term ''professional.'' Functional education of this character may serve as a preliminary stage in a professional discipline, to be completed by a more detailed training in problems and techniques after the choice of a more specialized calling. On the other hand it may serve as a terminal stage of formal education for persons aiming at more general pursuits.

Up to the present, the efforts to set these types apart in the American schools of engineering have achieved only a meager success. The Thayer School at Dartmouth, the former Graduate School of Engineering at Harvard and the six-year arts-engineering courses at Columbia have marked the nearest approaches to the strictly professional school of engineering, based on advanced levels of academic education. In point of enrollment, Dartmouth and Columbia have had only a precarious success. The graduate school at Harvard disappeared in the temporary merger with the Massachusetts Institute of Technology, but is apparently being reconstituted gradually out of the present undergraduate school.

What has been sought, and to some degree gained in these experiments, is not so much a more specific professional discipline, as a more liberal preliminary education. In point of contact and method, the instruction in engineering proper has not differed greatly from that in the strongest undergraduate schools; it has not been characterized by a more direct bearing on the actual situations and problems of engineering practice, nor has it afforded a more precise and detailed discipline in professional relations and responsibilities; and whatever it may have gained in intellectual rigor has apparently been due to a narrower selection of students and a more mature level of interest. It can not be said, however, to have established a type of engineering education as complete and self-contained as that given in the graduate schools of medicine, law and theology.

Notwithstanding their inconclusive results, these outreaches toward a more truly ''professional'' type deserve sympathetic interest. They have involved risks and costs which only rich and independent institutions could assume, but which may prove in time to be the price of a widely shared progress. If all the medical schools in the United States had been undergraduate colleges, with no successful examples on the graduate level, no pressure from the profession, no voluntary action by the schools collectively, no public legislation could possibly have wrought the change in standards which has marked the last two decades. Force of example was an indispensable factor, and, indirectly at least, the most potent one. The above statements should not be interpreted as a long-range plea for the transformation of all engineering colleges into post-graduate schools. Any such uniform standardization would be highly unfortunate. The point to be emphasized is that all engineering education might be the gainer if a few schools could give it a more salient professional character. This goal, however, is one for evolution rather than legislation to achieve.

Manifestly, there is little point in comparing functional undergraduate colleges of engineering with graduate professional schools of law, medicine or divinity. Comparisons with the undergraduate colleges of agriculture, commerce and education might be more pertinent—a process which would scarcely endanger the prestige of the engineering schools at any point. Where, as in the ratio of eliminations to admissions, the efficiency of the engineering colleges falls to a low statistical level, it may usually be traced to a compromise between the selective standards of a professional school and the open-door policy of institutions dedicated to personal adjustments and social upgrading.

In the present state of training and guidance in secondary schools, it seems inevitable that much of the process of selection on the basis of aptitude and interest must fall within the college period rather than precede it. The quality of preparation in specific subjects, English, mathematics and the like, has been shown to be a valid index of probable success in the continuation of the same and related studies. Certain additional aptitudes, such as skill in drawing and in manipulating tools and instruments are easily ascertained in advance and have positive predictive values for success in college studies, but we know all too little how closely any one or any sum of these abilities is related to actual performance in an engineering career. It is also difficult to determine in advance whether a boy has a dynamic interest in engineering activities. The taste for scientific and technical pursuits is much more likely to show itself first in the age range from 16 to 19 than at later maturity, but a youth of this age is seldom in a position to observe or visualize the work of an engineer or a chemist in its actual setting of activities and responsibility. He sees details, often interesting in themselves, but seldom samples of the job as a whole. The portrayal of these callings in fiction and on the screen is more often romantic than realistic. Unfortunately, few of his teachers or advisers in the secondary school are much better informed on these matters than he.

Genuine work samples, which are still the most valid tests of occupational aptitude and interest can seldom be provided in any significant number and variety before the aspirant has actually been admitted to college. A very interesting experiment in this type of pre-college guidance is the summer camp conducted by Stevens Institute. The freshman year in college affords many work-sample tests as it is, but these are usually casual and unrelated. Much more might be done if the year's program were under more unified supervision as suggested in a later section. Courses in drawing and surveying, courses in engineering problems and elementary laboratory technique, all offer interesting possibilities. Shop courses, as tests of engineering aptitude have been somewhat disappointing, whatever their value in other directions. On the side of negative criteria, it is certain that boys who have little taste for or ability in mathematics and science, are poor prospects for an engineering education, no matter how skillful they may be as practical craftsmen or experimenters.

Since admissions cannot at present be governed directly by aptitude, some check-up at an intermediate point in the course would seem appropriate, preferably at the end of the second year. To limit the two upper classes to men of well-proved scholastic and technical ability would be highly advantageous, while other students of good general ability would suffer little disadvantage from a change of program at this point. Experiments with an intermediate comprehensive examination should be followed with general interest, as should the development of specific aptitude tests for such traits as visualizing ability.

Summarizing the foregoing, it is the view that the normal type of undergraduate course in engineering is of a broadly functional character of equal value in itself and as a foundation for much more explicit professional training; that this type needs to be guarded from the encroachment of a vocational or ''ad hoc'' type of training, either for particular technical callings or for particular industries; that while it is neither possible nor desirable to restrict engineering education to a professional discipline, it would be equally undesirable to lose its present professional orientation; and that the highest type of professional education may ensue as graduate work in those engineering schools which maintain the fullest professional standards.

Social economy dictates that the functional type of engineering education be kept widely accessible. It is impracticable to maintain uniform levels of entrance and of graduation on a nation-wide scale; equally, it is impracticable to restrict the grand total of admissions or the number of schools active in this field. Accrediting of schools by national professional bodies offers the only effective protection of standards; above the minimum qualifying standards there should be wide latitude of local adaptation. A valid selection of students can not be made by any once-and-for-all process in advance, but grows out of a continuous process extending into the college itself; the early part of the curriculum with its associated teaching and testing processes should be directed more largely to this end.

To keep college aims clearly defined and college processes efficient when the colleges themselves are part of a confused and ill-organized larger scheme of technical education is at best a precarious undertaking. The engineering colleges owe it to themselves as well as to the larger public good, to use the influence of their national organization to bring together the other interested parties—public, educational, professional, and industrial—in some guiding agency comparable to the German Commission on Technical Education.

VI. Can Curricula and Teaching Processes Be Made More Effective?

Set a detached observer to appraise American engineering education and he would find colleges and schools in adequate number, well distributed relative to the population, educational standards for the most part equal to the best in respective local areas, an ensemble of equipment unequalled in the world, a student body of better than average endowments, a group of competent teachers including a fair share of men of distinction in their fields, a group of close-knit curricula with a minimum of dubious content, and an outflow of graduates well adapted to our current industrial life. In all, the educational fabric would exhibit a minimum of shoddy and a uniformly high average of strength. He might observe forces at work, however, which make for industriousness on the part of both teachers and students, rather than the more fertile and creative qualities of thought and action. His verdict would probably be that there are no glaring defects, but that conditions only occasionally rise above the higher levels of routine excellence.

He would find it difficult to make specific suggestions which if applied broadly, might lead to pronounced betterment. The standards of admission vary considerably, but in general are as high as local standards of secondary education will bear. The curriculum could be improved, no doubt, but changes within reason would probably lead to minor betterments in the final product. The faculties could be strengthened to advantage, but their qualifications are rising steadily and now approximate, on the whole, as high a selection of men as academic traditions and industrial competition will allow. Recommendations on each of these points for the most part, would need to be local and specific. Critical scrutiny points to the educational process itself—teaching, learning, testing, and specific features of its aims, to be concrete—rather than the mechanics of general organization, as the most promising area for betterments.

Our detached critic would be struck by the degree to which these educational processes reflect our national genius for quantity production. Pressed to get a maximum result in a minimum of time, engineering educators have borrowed, half unconsciously, from the management methods of industry. The essence of the scheme consists in first vizualizing the process as a whole, then dividing it into major steps in a logical progression, and finally breaking the work down into small units to be done in a definite sequence, under pre-arranged conditions and with the materials supplied precisely when needed and in the most convenient form; this task sequence to be carried out under close supervision, with continuous inspection and grading of piece parts, and the rewards to be paid in terms of a standard task with a quality bonus.

Our critic would note that while these methods speed up the production of unit tasks and give the performer a maximum of manipulative experience in a given time, they seldom lead to independent craftsmanship or to capacity for original creative work. From the viewpoint of the system, the supply of work materials is admirable; the standardized text-books and manuals seem to be an indispensable convenience. Our critic, however, would have misgivings, perhaps a suspicion that they break up the broad inter-relations of science artificially, that they cut the student off from contact with original sources, and that all too often they are meant to obviate most of the need for critical or creative thinking by student and teachers alike. Does the text-book, with its specially refined and pre-organized exposition, give any more insight into the processes by which knowledge is actually won, than flour in a sack suggests the cultivation, sowing, reaping, threshing and milling of a field of wheat? May not the piece-meal grading system with no comprehensive testing of the student's knowledge and powers, make for job production rather than a formative influence on the student's mind and personality as a whole? May not the regimented plan of work favor the industrious plodder, at the expense of the man of imagination?

The above statement, based as it is on an industrial parallel, is somewhat overdrawn for effect, but the contrast between industriousness in many a college and the lack of real fertility is patent enough. The principle of "the specificity of learning," to use a catch-word of the educationist, seems often to obscure or even to expel those broader and more subtle aims which the French so aptly describe as " the formation of the intellect," in contrast to "the acquisition of mental baggage." Our students are taught more content but are trained less as persons than their fellows of like age abroad; but the European is far superior in point of self-acquired information and in culture drawn from the stores of family and racial experience.

Not all of our teachers of engineering are blind to the defects of a system which exalts industriousness rather than fertility. A group opinion voiced by one of the early presidents of the Society is thus expressed:

> "The large majority of college and engineering students have been and are being trained to accept, to memorize and to take for granted, rather than to question, to analyze, to think for themselves and to develop mental initiative. They rarely distinguish between observations, definitions, conventions, principles, hypotheses. They have been and are being taught how to solve certain problems by approximate and superficial meth-

> ods without having a sufficiently sound scientific background of fundamental principles to enable them to appreciate the approximations involved and the corresponding limitations of their solutions. If education means mental training, they have not been educated; they have been shown just what to do and how to do it—in many cases they have it done for them—and they imagine that they understand.
>
> ''The fault for this situation lies in large part in the prevailing attitude of the teachers, many of whom have been trained in the same superficial manner. The fault also lies in part in the size of classes in most of our large universities, which makes it necessary to be content with teaching rules of thumb.''

This is a far more searching indictment than any which has been brought against the curriculum. Before passing judgment, however, it may be well to examine the backgrounds of the problem. The current educational theory in elementary and secondary schools largely denies the value of all imposed discipline and emphasizes the aim of self-discovery and personal adjustment. If the pupil engages in purposed and sustained mental effort, it is to be prompted by his own interest. The spirit of the secondary school especially tends to be receptive, appreciative and expressional, with few incentives to hard thinking. The aim of adjustment to life, in the absence of unusual stimuli, tends to create an intellectual level approximating that of the man on the street. If the student gains a superior scholastic record it may mean little more than reaching everyday levels of achievement with more than ordinary facility. Since the law requires every one to attend the secondary school, at least up to a prescribed age level, its program and standards must be such as to permit every one to succeed. Unless the leadership is exceptional the school becomes an epitome of the surrounding life, much of which is organized so as to minimize the necessity for close thinking by all but a few specialists, most of them too remote to be of value as examples. Do we not spend much engineering effort in order to make automobiles and refrigerators foolproof? Do not advertisers aim to reduce our purchasing to conditioned reflexes? Do politicians offer issues to the voters, or slogans and emblems?

Given the product of a secondary education deficient in intellectual rigor, what are the engineering colleges to do? Reject four-fifths of it? Unsocial in principle and impossible for most institutions. Insist on further academic preparation in a college of arts or a junior college? Inexpedient as a general rule, though highly desirable in individual cases. Given a limited time—limited both by the student's means and by his incentives for formal education—in which to prepare him for an exacting calling, given the insistent demands of industry in normal times for technical recruitment at an adaptable age and at a moderate level of scientific attainment, the natural and perhaps inevitable response of the engineering colleges is to impose an upgrading discipline and a regime of work which economizes time to the limit.

However urgent may be the disciplinary quality of the early part of the college program, modifications in the direction of greater freedom may be highly advisable as the student matures. Reduced to their most elementary terms, the college attempts to do four things: (1) Train the student to do work of an amount and quality, particularly in point of rigor and precision, in advance of his previous experience; (2) equip the student with the scientific data and tools of his prospective occupation and their modes of use; (3) orient the student to the economic functions and social duties of this occupation; and (4) develop in him an engineer's habits of analysis and planning. While it is scarcely practicable to allocate these aims to particular periods a consistent progression may be noted; in broad terms the first and second aims dominate the first year; the second and third together, the intermediate years; and the third and fourth, the final year of the undergraduate program. Actually few engineering curricula give evidence of any such intentional progression in objectives. The logic which appears to dominate the planning of the curriculum and teaching processes in most instances is more impersonal, if not routine. The planning process appears commonly to follow some such order as this: What total content of knowledge and skills shall we aim to impart? How can it be divided most conveniently and in what sequence? From what source or by what experience can each unit be supplied most conveniently? Who shall teach each unit? What check can be kept on the student's achievements and what total shall be counted as a satisfactory minimum? That is, once the sequence is mapped out, planning and supervision are focussed on the units of instruction much more largely than on the total effect to be produced in the student. The saving grace in the situation is the generous personal interest and counsel by which deans, department heads and teachers of the rank and file compensate for the lack of formative influences in a much divided and formalized curriculum.

Our detached observer would be impressed by the dominating influence of the text-book and the formalized laboratory exercise in nearly all our schools. The unit process idea, the recitation method of teaching, the complex plan of operations in the larger schools, the excessively wide range of teaching attempted in a large proportion of the smaller schools, the limited qualifications of many of the teachers, and the piecemeal grading system are all part of the same characteristic American picture. The engineering schools of Europe proceed on the principle that it is essential above all else to have teachers of original and commanding authority whether the group to be taught is one of ten or one of a thousand, that the student must be expected to do his own thinking under authoritative guidance rather than to find it done for him in advance in a text-book, and that the experiences of the laboratory are rather to be analyzed exhaustively than to be performed in great variety for the manipulative experience. As often pointed out, European systems, with their stress on the conceptual side, succeed well only with superior minds; the American system with far greater stress on the manipulative side is likely to be much more serviceable to the industrious man of average mentality. The work of our strongest institutions has in general been well adapted to superior minds. As a common observation, however, many of our schools appear to have been content in the past to fit their systems to the average man or to the modal group in the middle range of abilities.

While none have been indifferent to individual differences, many colleges have actually given scope to these differences only in the degree of speed or excellence with which the student executed the details of essentially uniform programs. While this system has not worked badly, its inadequacy is being more and more recognized, as the growth of honors courses and of individualized forms of advanced work clearly evidences. These newer plans recognize that the most significant differences between superior and average students is more often in the manner in which their minds work, than in the differences of pace or excellence of execution of details.

American teaching methods tacitly imply a distinction * which is seldom pointed out—that between *student* and *learner,* between one who assimilates the recorded experiences of others and one who learns very largely from his own experience. The ''student'' quickly passes from original phenomena and data to a conceptual mode of thinking, which aids him greatly in expanding his area of mastery and in assimilating knowledge in fairly abstract or symbolic forms. The ''learner'' proceeds from experience to experience, with only incidental aid from primary sources. If he is of a reflective turn, he may build up a conceptual system for himself; if not of a reflective turn, he is unlikely to reach the stage of generalized thinking but merely to link up his experiences in habit systems. In this somewhat special sense, the ''student'' is the exceptional type and the ''learner'' the prevailing type in the American engineering college. In France, the reverse is true, as a result of an intensive process of selection, and each system has the defects of its virtues.

Our detached observer would note that the typical engineering student, to resume the colloquial sense, works and learns efficiently only when set to his daily quota of tasks. As a rule, he does not thrive on independent study. Very few of our engineers, whether in practice or in college, are book-minded. It has not been the practice of many engineers to collect professional libraries such as able lawyers, physicians, architects and clergymen find indispensable. Until the recent growth of a wider interest in research, very few engineers have had recourse at any time to original sources; in college they received their daily ration from text books and in after life have grown to depend almost wholly on handbooks and periodical literature.

---

* The writer recognizes that this terminology is somewhat artificial, but believes the idea is valid.

While distinct gains have been made in recent years, much yet remains to be done to inculcate a scholarly taste and habit in the ablest men growing up in the profession. The source of this deficiency is largely in the predigested materials of instruction and the all too prevalent failure to acquaint the student with the original processes by which engineering knowledge has been and is being won. With all its wealth of technique and its recognized proficiency in execution, it is not wholly surprising that the engineering fraternity has at times found difficulty in gaining acceptance as a ''learned'' profession, in view of its weak sense of its traditions, its slight knowledge of its historical development and its nebulous philosophy of its social functions.

Were we facing positive defects, radical remedies would suggest themselves, but the conditions cited are essentially negative. Many college men tacitly accept them as natural or inevitable. The educational organism appears to be structurally and functionally sound, but in some respects below par in vitality. If so, there may be more need of a change of atmosphere and regime than any radical reconstruction. The first concern should be for a re-vitalized teaching force.

Among American engineers the teaching group, both in the past and the present, has enlisted more than its proportionate share of the men of high intellectual fertility and of personal attainments. The total number of teaching posts is very large, however, and the comment is often made that the American teacher of engineering as a type brings to his task less intellectual and professional equipment and less breadth of personal culture than his confrere abroad. He wins his place with little stress of competition and has only a modest tradition of prestige to maintain. When the young instructor is left to his own direction and has occasion to deal mostly with immature and uncritical minds, he finds it easy to slip into routine ways.

While teaching is a work of supreme importance, it does not provide within itself for the renewal of the sources of personal fertility. Under the weak competitive conditions which have prevailed, far too many men have drifted into engineering faculties along a line of least resistance. The man who is seeking escape from the ruder conditions in industry, the timid man craving a sheltered life, the uplifter bent on doing good in a vague expansive way, the dilletante who scatters his interests, the man of good intellect but lacking in personal drive—all are likely to make an enthusiastic start, then find their motive power running down, slip into low gear and become either routine or ineffectual. The large number of junior positions in an engineering faculty, as contrasted with a school of medicine or law, increases the probability that infertile teachers will accumulate unless vigilant measures are taken.

The better engineering colleges are insisting on higher scholarly qualifications in their appointees, but are wisely avoiding any slavish insistence on the Ph.D. degree. The conventional graduate school with its discipline in specialized scholarship and minute research is probably not the best place to train the great body of engineering teachers. Graduate work in engineering is of rights a complementary professional training with stress on the investigative function. The more original types of engineering practice present an endless series of research problems of a moderate rather than profound order, and it is probably wiser in nine cases out of ten to inculcate the habit of original inquiry by a succession of problems, culminating in one project of fair magnitude, than to demand a single *tour de force,* such as the Ph.D. thesis has become.

An idolatrous devotion to research would be alien to the spirit and traditions of our engineering colleges. Experience shows all too clearly, however, that if the fertility of the engineering teacher is to be maintained he will need to cultivate some field of creative activity apart from teaching. Four collateral activities suggest themselves which are of the same order of worth, if pursued on a high level of intellectual effort: (1) research proper, (2) original contributions to engineering practice, (3) service to the scientific or technical professions in their major organizations and (4) the advancement of educational technique in forms serviceable to other teachers. To engage in engineering practice of a conventional character is of unquestioned value to the teacher, aiding the novice in building up background, judgment, and a sense of confidence in his practical capacities, and helping the mature man to keep abreast of the art. Long experience in practice has probably been much over-rated as a qualification for teaching and the present tendency to fill the higher posts by the advancement of promising juniors has much to commend it. Unfortunately much of the practice done by the young and often poorly paid teacher consists of pot-boilers for revenue only and is of little more professional value than over-time teaching in evening or summer school. Text-book writing has been so exploited under commercial pressure that there is little original authorship in the whole fraternity of engineering teachers. Few juniors withstand the temptation of quick returns in order to pursue the more arduous but ultimately more rewarding path to authoritative knowledge which might qualify them, like their European confreres, as originators of the art or as consultants to industry and to regular practitioners.

The college administrator who strives to lift teaching above the conventional plane faces the stubborn fact that there is no open market for superior teaching talents. If present deficits are to be filled and future standards advanced, men of promise must be caught young and groomed for a teacher's career. Industry does not leave recruitment and grooming to chance and it appears to be a precarious policy for the college.

Viewed as a whole, our methods of selecting and training future teachers are less effective than the practices of the more advanced industrial concerns. Choose two young men of equal ability and place one in a progressive industry and the other in a junior teaching post; the odds are fairly great that the man in industry will be ready for promotion to a place of considerable personal responsibility long before the young teacher. In the writer's observation, the critical period in the development of the engineering teacher falls in the early thirties, and is associated with the usual slow advancement in income and responsibility at this stage of his career. This condition might be largely averted if colleges were to appoint instructors after one or two years of graduate study or industrial experience of a broadening type, test their promise as teachers in a probationary period of two or three years, then map out a complementary program of specialized preparation with each individual who is to be groomed for a permanent appointment. This complementary training would involve further graduate study in some instances, temporary placement in industrial staffs or laboratories in others, specialized practice in others, and in some cases a period of discipleship under a man of outstanding authority. The college should provide financial aid where needed and use its influence to effect the most advantageous placement.

A college which follows some such deliberate policy of developing men for higher teaching appointments should expect to lose some of its prospects, both to industry and to other institutions, but if the plan were more generally followed it would greatly increase the supply of men of high ability who are qualified at or before thirty for assistant professorships with individual responsibilities and reasonably attractive salaries.

While more positive measures to train young engineers for teaching careers would make it possible to upgrade the present staffs with fair rapidity, a marked advance can hardly be expected until the colleges and the industries have reached a better working understanding on the status of the professorial career. On the part of the college, the problem is to invest the higher positions with greater freedom, larger means of professional achievement, and wider authority. On the part of industry there is needed a wider disposition to place or to leave creative men in professorial chairs and to use their services in consulting and research capacities without terminating their teaching careers. This policy may seem utopian, or at least incompatible with the ultra-competitive spirit which has ruled American industry in the past. The professor's chair in Germany has been inviolate to competition from industry, largely as a result of a social philosophy which places the interest of the nation above that of the individual person or concern, and, in consequence, relies on socialized rather than competitive measures to insure leadership and progress. A similar spirit and philosophy are slowly gaining ground in the United States.

As has been suggested above, the most fruitful changes in curriculum and teaching processes are likely to be in the realm of the spirit and regime of work rather than in the mechanics of programs and schedules. A few suggestions are offered, with a view to making the issues concrete:

1. To organize the freshman year under more centralized supervision with the dominant aim of giving the student more effective training in methods of study, systematic work processes, clearness of expression, standards of accuracy, orderliness and punctuality, and problem analysis—in a word, to focus attention on molding the novice into an efficient engineering student. The present subject matter lends itself admirably to these ends but integrating influences are usually lacking or deficient. As a rule, the student passes either at the beginning or at some intermediate point of the second year under the tutelage of a professional department which is thereafter responsible for the integration of his further training. The writer would suggest an analogous supervising department for freshmen; the teaching of graphics and problem courses would fall within its sphere; and its head should be a man of calibre, rank and responsibility comparable to the heads of civil, mechanical and electrical engineering. The staff might well include an expert educational clinician, some one to prepare and apply placement examinations, diagnostic tests and individual remedial measures, but the head himself should be an engineer with some genius for personnel matters rather than a psychologist or a subject-matter specialist.

2. To devote the second and third years principally to ac-

quiring the scientific data and tools of some major division of engineering, much as at present, but to supplement the present rather detailed class and laboratory teaching with collateral processes of somewhat broader aim, as for example: (*a*) by lectures which introduce the student to the original sources and to the experimental and analytical processes from which the present body of scientific and technical knowledge has been built up, and (*b*) by requiring in each of the four semesters a project of design, analysis or elementary research considerably beyond the magnitude of the usual laboratory experiment or day-to-day problem. These projects would be done semi-independently under the supervision of the student's professional department, and each covered by a report such as an engineer might submit to a client. Ordinary laboratory work, on the other hand, would be recorded in much simpler memoranda, such as a research or development engineer would preserve for record purposes. Project teaching should aim to develop in the student a more assured grasp of the engineer's method of work (problem analysis and selective solution) than is possible in small-scale exercises, and to appeal to his initiative, resourcefulness and originality.

3. To separate the fourth-year class or possibly both the third- and fourth-year classes into regular and honors groups; to provide the former with a quantitative program, based on a regular schedule of work; and to offer the latter a qualitative program similar in form and method to that of a post-graduate school. Where work is offered for the M.S. degree, the senior year of the honors group might be included in a two-year program with this objective. Teachers should be encouraged to depart as far as efficiency would allow from a schedule of day-to-day assignments with the regular group and to abandon them entirely with the honors group.

VII. THE PROFESSIONAL PHASE OF THE ENGINEER'S EDUCATION

We have characterized the college curriculum in engineering as functional rather than professional. That is not to minimize its value to the professional engineer, but to emphasize its broader utility. A majority of engineering graduates do not enter a profession, unless we use that term in in its loosest sense. Instead, they enter upon business and industrial careers in which technical knowledge is known to be useful, if not indispensable, expecting to advance to executive positions. A much smaller number, probably not more than a third of the whole body of graduates, advance into the more highly skilled and individualized status of the professional engineer.

It is impossible to separate the two groups before graduation, much less at admission to college. The process actually proceeds by natural selection during the whole period of orientation to practical life. In college, the same course of study must serve both groups, equally well if possible. After differentiation, each may receive further training according to more specific needs. The present undergraduate course pursues the common path about as far as is practicable. As one group advances in industrial life, it finds needs for more specific technical knowledge and a broader grasp of business organization and administration. The graduate who aspires to a more distinct professional status, however, soon discovers his need for more profound and wider technical knowledge, but is less likely to be confronted early in his career by problems of general management.

The movement to prolong full-time training for the professions into the later twenties has apparently reached its peak and entered a decline. The question to be faced in view of the growing complexity of industrial occupations is not how much total education does a given youth need in order to succeed in his prospective calling, but how much does he need in advance if he is to enter upon it auspiciously and to make further progress as rapidly as his needs develop. The engineer, unlike the physician, seldom enters his profession at a self-sufficient level of responsibility, nor can the direction of any individual's progress often be foretold in advance. He finds it an advantage to begin active life at a fairly plastic age, provided he can be assured of opportunities and incentives for further education. Engineers are in an exceptionally favorable position among the professions to work out a discipline based on a combination of full-time functional education in late adolescence and part-time professional education in the early and later adult years.

Longer full-time education is highly desirable for a selected minority of those who now complete the undergraduate course, but probably would not lead to proportionate gains in either technical proficiency or in social orientation if required of the entire body of graduates. Higher technical proficiency means higher specialization than most students need or desire, and social and economic wisdom in the broader sense is hardly to be gained in advance of maturity and experience in the world of affairs. The adult phase of education should contribute largely to these ends, leaving the adolescent phase relatively free for the mastery of the basic intellectual tools.

With minor readjustments the present college curricula in engineering would serve admirably as a foundation stage in a coördinated program of adolescent and adult education. If further training in a graduate school or in life after graduation can be guaranteed, the amount of technical detail taught to undergraduates could be considerably reduced without lessening the employability of the graduate or limiting his capacity for further progress. The sciences might then be covered more thoroughly and the humanistic features moderately enriched, especially in the upper years.

The student who aspires to a highly scientific or technical field of activity should endeavor to get a fifth year in college if possible. The surest way to accomplish this is to continue directly after graduation. Once launched in practical life there is less likelihood of his return to college, but if he does his period of experience will usually add greatly to the value of his higher studies. It is often assumed, if not asserted, that only principles can be taught in college, and that the tying of principles to practice which is the very essence of professional training can be done only in the realistic world. This has been largely true in American experience, but Europeans have gone far beyond us in making the higher engineering schools actually professional. Three conditions seem to be essential to this result: (1) that the professors be practitioner-specialists of the first rank, (2) that the students be ready to accept the consequences of specialization, and (3) that the students shall have had realistic contact with practice.

These conditions are approximated in the post-graduate divisions of a few American institutions. The graduate school provides an indispensable professional training for at least one important phase of engineering—the field of research. It is almost futile to put the ordinary graduate into research work, even under the ablest direction, and to expect him to improvise the training for its special functions. Engineering research staffs have been recruited in the past largely with physicists and chemists. In the larger laboratories where studies in fundamental phenomena have a large place, this type of personnel fills an indispensable rôle, but a highly trained research engineer is usually much more effective in bridging the gap between pure phenomena and commercial application. Research training is scarcely less important in process development than in originating new products and applications. Except for temporary recessions, the market for research and development engineers appears to be far below saturation. It is only a matter of time until even the smaller industries will be forced by product competition into research as a means of survival.

The complements of professional training for the graduate who is to be concerned with design, construction and application are not so clearly the task of a graduate school. The teaching of design lends itself to a systematic discipline, in so far as it embodies rational rather than purely empirical procedures, provided the teachers are of adequate learning and experience. To an increasing degree it is taking its place in the graduate schools, but there are still many fields of design for which much of the necessary training must be gained through experience and discipleship, rather than formal instruction. Industry has accepted in principle its duty to supplement the college course, but its training processes—with some notable exceptions in the electrical industries—usually aim at fairly immediate practical ends rather than the rounding out of a professional discipline. The graduate engineer who is privileged to spend at the outset of his career, a period of discipleship under some master mind is exceptionally fortunate. In recent years the personal disciples of Steinmetz, Lamme and Jewett have left a striking impress on the electrical industry and similar examples could be multiplied in other branches. It is unfortunate that men of these qualities are less often to be found in our professorships than in our major industries or in personal practice, and that the American public sanctions this condition as a normal consequence of its individualistic, competitive philosophy. Yet there are many professors of such authority and distinction that their guidance and discipleship may be followed with high advantage.

Under these conditions the ideal arrangement is for school and industry to join forces on the post-graduate level, as at Union, Massachusetts Institute and Pittsburgh. Formal cooperative plans for training graduates are not practicable in the majority of cases, nor do school and industry complete the roster of educational agencies. By tradition and practice, education is one of the chief functions of the major professional societies. The difficulty to be overcome in rounding out a professional discipline through a flexible scheme of adult education is not so much in providing the necessary elements —colleges, training courses, extension schools, conferences, lectures, periodicals, libraries and numerous other agencies are ready to contribute whatever may be required—as in shaping the process into something coherent. Metaphorically speaking, we have or can easily obtain all the ingredients of the educational concrete, but need some one to provide the forms, to supervise the mixing and placing, and to inspect and certify the result. In the absence of any adequate public authority, this is clearly the responsibility of the organized profession.

It must be admitted that the national bodies of engineers are at present ill equipped for any such task. The profession is divided in organization, has no common voice and is only slowly acquiring a corporate consciousness. It has no tangible code of educational qualifications, but accepts a go-as-you-please training and bases its professional status on mutual recognition of competency. Beyond a few generalities and a few details, it is unprepared to guide the schools in their regular operations, much less to set up forms and controls for novel forms of adult education. Yet the thing can be done and the engineering profession can in time be induced to do it. In fact, it is being done under fairly parallel conditions in the actuarial and accounting professions. Furthermore, it is a function strikingly in line with the original purposes of the older engineering societies.

Before expanding this proposal, it may be relevant to consider what a corporate profession is and what its social responsibilities are. Of professions there are many kinds; open professions like music, to which any man may aspire within the limits of his talents, and closed professions like medicine, which may be entered only by a legally prescribed process; personal professions like painting and social professions like law, whose members constitute "the bar," a special class in society; private professions like authorship and public professions like journalism; artistic professions like sculpture and technical professions like surgery. Despite these differences all these callings have certain attributes in common which constitute the professional stamp.

All recognize that some of the attributes of a profession pertain to *individuals* and some to *groups*, but there is considerable variation in the emphasis given:

ATTRIBUTES OF INDIVIDUAL PROFESSIONAL LIFE:

1. *A type of activity* marked by high individual responsibility and dealing with the problems on a high intellectual plane.
2. *A motive of service* which takes precedence over profit.
3. *A motive of self-expression* which implies a joy in one's work and a single standard of workmanship —one's best.
4. *A conscious recognition of social duty* to be accomplished, among other means by:

- *a.* Sharing advances in professional knowledge.
- *b.* Guarding the standards and ideals of one's profession and advancing it in public understanding and esteem.
- *c.* Rendering gratuitous public service, in addition to ordinary professional service, as a return for special advantages of education and status.

Attributes of Group Professional Life:

1. *A body of knowledge* (science) *and art* (skill) held as a common possession and to be extended by united effort.
2. *An educational process* of professional aims, which implies a constructive share by the professional group in the ordering of education.
3. *A standard of qualifications* for admission to the professional group, based on character, training and competency.
4. *A standard of conduct* in relations to clients, colleagues and the public, based on courtesy, honor and ethics.
5. *A recognition of status* by colleagues or by organized society, as the basis of good standing.
6. *An organization of the professional group* based primarily on common interest and social duty, rather than economic monopoly (not universal in the artistic professions).

The public grants a corporate profession tangible monopolies and privileges, in consideration of which the organized body engages to admit to its membership only men of proved competency, to scrutinize the quality of their work, and to protect the public against extortion and bungling. The occasion which calls for professional service often represents a human emergency. The knowledge or skill involved is often too esoteric to be judged by an ordinary layman. In many cases the safety of life and limb or the preservation of public health or morals are at stake. Under these conditions the legal doctrine of *caveat emptor*—"Let the buyer beware"—breaks down. The public puts the burden of guaranteeing at least certain minimum standards on the profession itself, and in return protects the profession from incompetent criticism by laymen.

Since a profession must so largely govern itself, it is assumed to maintain certain codes:

1. A code of qualifications governing admissions.
2. A code of ethical practices in relations with clients.
3. A code of professional honor in internal relationships.
4. A code of public obligations.

Professional status is therefore an implied contract to serve society in consideration of the honor, rights and protection society extends to the profession. Through all professional relations runs a three-fold thread of accountability to colleagues, to clients and to the public.

The obligations of a profession are so much a matter of attitude that codes alone are not sufficient to sustain them. Equal importance attaches to the state of mind known as professional spirit, which results from associating together men of superior type and from their common adherence to an ideal which puts service above gain, excellence above quantity, self-expression above pecuniary incentives, and loyalty above individual advantage. The professional man cannot evade the responsibility to contribute to the advancement of his group. His skill he rightly holds as a personal possession, and when he imparts it to another he rightly expects a due reward in money or service. His knowledge, however, is to be regarded as part of a common fund; hence, the obligation to publish researches and to share advances in professional practice.

The healing art is a realm of stratified professions—physicians, dentists, laboratory technicians, optometrists, nurses, midwives, etc. The novice does not graduate from one level to another; instead, he selects a particular calling, prepares himself for it specifically, and follows it permanently. This definite grouping accentuates professional status. As engineers, our traditions are precisely the reverse; between our ranks there is unlimited vertical mobility; our organizations are inclusive of all ranks; and our education has aimed at the widest range of individual adaptability. Engineers enjoy the widest possible choice of activities, without impairing their inclusion in the profession, but this very catholicity lessens their chances of public recognition as members of a professional aristocracy.

The movement to place the practice of engineering under public licensure has reached such proportions as to bring to a focus the question whether the profession is to set and maintain its own professional standards or to look to public agencies. Licensing, as it has developed in other professions, is primarily for the protection of the public. In personal emergencies laymen are not always able to discriminate between the competent, ethical practitioner and the shyster, quack or charlatan. Incidentally, licensing tightens the monopoly of a recognized group, tends to restrict accessions and usually stiffens educational standards. It is still too early to estimate how much protection the public gains from the licensing of engineers; some, undoubtedly, under all circumstances and perhaps much in the non-industrial areas where few laymen can have first-hand knowledge of engineering standards and personnel, and where practice is still largely in the hands of individuals. In these areas the engineer receives much the same degree of protection as the public. Where engineering practice is in corporate rather than individual hands, licensing affords only nominal protection to either practitioner or public. In structural practice, where the engineer comes into contact, and at times into competition with the architect, it is essential that the rights granted to one shall not infringe the rights of the other, and that regulations shall affect the two impartially. Engineering has less need of restriction in numbers than the professions of individual service. The number of doctors, dentists or lawyers required per million of population is fairly inherent, but there are no inherent limits to the application of scientific techniques to economic processes and utilities. Thus far the effects of licensing on the professional standing of engineers have been nominal, as have the effects on educational standards. The *status quo* has simply been written into legal regulations. In time, however, licensing may assume great importance as a restrictive measure in the use of titles and may potentially operate to tighten educational programs and standards.

Licensing supplements but does not replace the responsibility of the organized profession for safeguarding professional standards. While the engineering colleges and the engineering societies sprang from different roots and developed independently of each other, both are to be regarded as educational institutions. The educational motive clearly dominated in the original purposes of the societies. The oldest of the national organizations of engineers is the Institution of Civil Engineers of Great Britain. In the official account of its founding we read:

> ''It was toward the end of the year 1817 that a few gentlemen, then beginning life, impressed by what they themselves felt were the difficulties young men had to contend with in gaining the knowledge requisite for the diversified practice of engineering, resolved to form themselves into a society.''

From the outset the Institution distinguished between its seniors and its novices by prescribing that a *member:*

> ''shall have been regularly educated as a Civil Engineer, according to the usual routine of pupilage.''

and by enrolling as *graduates* those:

> ''who have not been less than two years in the office or works of an engineer.''

Pupilage was a form of personal discipleship which usually followed what we would now call a secondary education and covered a period of from three to five years. The Institution, it may be noted, made no prescription as to the novice's general scientific education. It did, however, undertake to guide and supplement his more specific professional training. When, some decades later, technical schools and university chairs of engineering were established, their avowed aim was not to displace pupilage, but to supplement it with a more ample scientific preparation.

The second great prototype organization, the *Verein Deutscher Ingenieure,* grew out of an association of students at the industrial academy at Berlin which maintained under the homely name of *Hütte* a center where voluntary studies, researches and discussions were carried on as a supplement to the formal teaching of the lecture room. As the graduates scattered to the various industrial centers of Germany branches of the *Hütte* were formed as meeting places and centers of further education for the novices of the profession. Out of this effort grew a national union, at first composed largely of students, novices and professors, which in time developed into the chief national body of the engineering profession.

Neither of these prototype organizations undertook to provide or to regulate the formal or preliminary education of the young engineer, but each was set up primarily to aid the novice in the period of adjustment between the school and the full responsibilities of practice.

The early engineering schools in America were established before any formal organization of the profession. In a new country with only a few widely scattered practitioners of engineering there was little opportunity for pupilage to gain a foothold and the schools of engineering developed in this gap out of a simple necessity. As professional societies have come into existence after college courses in the several branches of engineering had been well established, the societies have offered advice and guidance, but have consistently left the ordering of college programs and standards to the educators themselves. On the whole, this policy has proved its wisdom. Engineering education has remained free from any such strait-jacket as that borne by the medical schools; it has remained free to experiment, to develop new types, and to adapt itself to the needs of different localities and types of population. What standardization exists can not be laid to the organized profession; it has rather been self-imposed by imitation and by the prestige-hunger which seeks to proclaim a prairie college "the same as Cornell" or a Y. M. C. A. school a "university."

These traditional functions of college and profession are so deeply rooted that it would be unwise to disturb them. Let the colleges keep the control of the broad, functional training preliminary to individual specialization in their own hands, with the professional body as an advisor and collaborator. Let the post-graduate divisions develop as advanced professional schools of engineering research and development. Let the organized profession retain as its special spheres of responsibility the complements of professional training which follow the college period and the continuing education of the adult engineer, with the colleges as coöperating agencies. For the early, functional phase of education we have the highly organized and relatively efficient programs of the colleges. For the adult phase we have the elaborate programs of society activities and the brief clinic-schools which certain of the colleges are now developing for practicing engineers. The weak link lies in the middle of the chain.

In order to make the scheme organically whole and sound, concerted and positive measures should be taken under the leadership of the national professional societies, to organize the period of novitiate into a much more orderly and effective educational process. The varied activities of the present, some orderly and many informal, are all good but the whole effect as far as creating a recognized professional status is concerned, is casual and chaotic. Sharp specifications and highly standardized tests of professional status are doubtless inadvisable, but it should be possible for the profession to set up educational guide lines, provide incentives, apply reasonable tests of achievement and give due recognition for further education beyond the limits of formal schooling.

The profession is by tradition an open body, welcoming to its fellowship men of formal training and men whose qualifications have been won by a life of studious labor; it is an inclusive body, with gradations open to men of all ranks of responsibility and with a zealous regard for the ideal of vertical mobility. This body of tradition is admirable, but the profession needs more than an open association of like-minded men, banded together for an interchange of experience. It needs an inner nucleus of highly qualified men whose professional qualifications and standards are so clearly attested that the public cannot possibly mistake them. As the most promising means of developing the novitiate into an effectual educational process and of enhancing the status of the inner nucleus of the profession, a comprehensive educational program culminating in a plan for professional certification should be set up jointly by the engineering schools in association with the major professional societies. Educational guide lines should be laid down to indicate what the profession regards as indispensable and what as desirable training beyond the scientific fundamentals for the diverse functions of engineering; several main categories and possibly many secondary ones would be needed, and the guide lines set up in each would allow still further latitude for individual situations. The incentives offered should not be wholly intangible; efforts should be made to induce employers to recognize steps toward professional certification and its attainment in advancing young engineers in rank and salary. More specifically, the writer would suggest the following features:

1. Certification by professional societies should be earned and not granted as a mark of honor.
2. There should be a code of educational qualifications more advanced than that represented by graduation from college, yet attainable by both college and non-college men.
3. Qualifications under this code should be tested individually and not gauged by personal estimates and testimonials alone.
4. These educational qualifications should comprise scientific, technical, economic and civic knowledge of a mature order.
5. There should be a code of experience qualifications which would make the normal age of certification fall between twenty-five and thirty.

6. The ultimate certification of graduates should be a goal to which colleges and professional societies should jointly lend their influence. To this end the colleges should be encouraged to limit the award of professional degrees to those who have attained this goal.

A comprehensive plan of educational guidance and certification, sponsored and supervised by an agency representative of the profession at large, covering the entire process of development from the choice of career to the coming of age in the profession, exacting in its standards but flexible in its details, and expressing the social responsibilities of engineering no less than its technical qualifications, would do more to enhance the public standing of the profession and to clarify the problems of the engineering schools, than any other one measure now within the range of practicability. It would leave the profession open to men of every degree and type of formal education who are able to meet adequate professional standards; it would create no legal monopolies, nor would it conflict in any way with reasonable and proper licensing laws; it would leave the fellowship of engineering societies open to the executive as well as the professional; it would leave their membership inclusive and not too rigidly graded; it would not impose on the societies invidious duties of regulating details of school and college training; it would place no strait-jacket on educational freedom and pioneering. But it would create within the now hazy boundaries of the profession an inner nucleus of highly qualified men whose professional standing and standards the public could not possibly mistake; it would give form and direction to the now after-college phase of the engineer's education; it would go far to create an articulate philosophy of social functions and duty within the profession; and it would make it more attractive to young men of the finest gifts and spirit.

The colleges would gain from such a plan in both tangible and intangible directions. It should draw to them more highly selected student material; it would leave them free to give a broadly functional or a highly specialized education as they might choose and one adjusted to local levels of preparatory education and individual welfare; it would add incentives and set goals for part-time and full-time post-graduate courses; by the incentives and direction given to after-college education, it would relieve some of the present congestion of curricula; it would give some objective measure of the quality of each institution's product, after a fair period of adjustment and testing in active life; and, through the joint agency which would be needed to guide and administer the system of certification, it would give the colleges a genuinely organic partnership with the professional body.

As this concluding word is being written, the national societies are taking the first steps in creating a joint committee on educational guidance and the certification of engineers. It is gratifying to record that the impetus of this action came largely from the coöperation of the societies and the colleges in these investigations. Should the project come in due time to realization, it would be a happy fruition of these labors of love, in which so many educators and engineers have shared.

June, 1933.

GENERAL REPORT OF THE SUMMER SCHOOL FOR ENGINEERING TEACHERS, 1927–1933 *

H. P. HAMMOND †

The Summer School for Engineering Teachers has been conducted under the auspices of the Board of Investigation and Coordination of the Society for the Promotion of Engineering Education as a collateral project to the general Investigation of Engineering Education. As the results of that investigation indicated that raising the quality of teaching—always a dominant purpose of the Society—is one of the most fruitful means of advancing engineering education it was logical that practical measures should be taken to that end. Accordingly, the Summer School was established. Begun as an experimental enterprise, it has now (1933) completed its seventh year. This period, during which twelve sessions have been held, furnishes the observation and experience upon which the following account of the enterprise is based.

General Summary

The summer school has as its primary purpose practical aid to the engineering teacher in solving the problems that

---

* Additional articles relating to the Summer School, describing one of the sessions in detail, presenting comments of those who attended, and appraising the results will be found in the following references:

''The Summer School for Engineering Teachers, A Practical Step Toward Improving Methods of Teaching,'' by H. P. Hammond, ''Proceedings'' of the Society for the Promotion of Engineering Education, Volume XXXVI, page 109.

Bulletin Number 14 of the Investigation of Engineering Education, printed also in Volume XXXV of the Society's ''Proceedings,'' pages 362 to 454 inc., 521 to 620 inc., and 670 to 726 inc.

''A Brief Report and Impressions of the Summer School for Engineering Teachers at Cornell University and University of Wisconsin,'' by H. P. Hammond, ''Proceedings'' of the Society, Volume XXXV, page 11.

Report of the 1930 Survey of Engineering Education, page 1209.

Consult Publications of the Board, (c) Summer Schools, page 1282, and Bibliography, pages 1290, 1299.

† Director of Summer Schools, Society for the Promotion of Engineering Education, 1927–33; Professor of Civil Engineering, Polytechnic Institute of Brooklyn.

confront him in the classroom. It is intended to provide centers for the study of teaching problems; to bring the teacher into direct contact with the ablest men in his field; to bring to his aid the experience and the methods of the professional teacher of education; to acquaint him both with the well-tried and with the newer methods of instruction; to give him opportunity to discuss his individual problems with fellow teachers under conditions that will promote a free and informal interchange of ideas; and it is intended, above all, to stimulate him to further effort to bring his instruction into line with the rapidly changing social and economic influences that surround education and engineering.

Sessions of the school have been held annually in various institutions throughout the country, each session being devoted to a particular course or division of the curriculum. Since its establishment in 1927, twelve sessions of the school have been held. When the Summer School was established it was planned to follow this system of rotation of subjects so that in time all of the important divisions of engineering study would be considered. The first cycle of sessions has now been completed.

Programs of the sessions included lectures, model teaching exercises, laboratory and lecture room demonstrations, seminars, and work carried out by committees of members of the groups. Methods of teaching are stressed in all parts of the programs; subject matter being considered chiefly in its relation to method. At each session advanced phases of the subject under consideration are presented with the purpose of stimulating interest and promoting further study.

The sessions are intended to stimulate an *esprit de corps* among the teachers of each subject and to promote supplementary activities carried out subsequent to the sessions. This purpose has apparently been accomplished: One new division of the Society has been established (on physics); seminar groups have been formed in various faculties for the study of teaching problems; and a number of teachers have later pursued advanced courses in various subjects.

The teaching staffs of the school comprise many of the foremost teachers of engineering, scientists, engineers and industrial leaders of the country. The staff of each session includes a director and a secretary chosen from the local faculty, a group of teachers of the subject under consideration, a professional teacher of educational method, and a number of specialists in various fields of education, science and industry.

That the summer school fills a definite need is indicated by the response of those it was intended to serve. Enrolments in the sessions of the first year numbered eighty-two, a number considerably in excess of expectations, and increased, in later years, to as many as one hundred eighty-seven. Teachers attending the sessions have been widely representative of institutions, sections of the country, academic rank, age and experience, a single session having included teachers from sixty colleges and universities.

Since its inception, the Summer School has been conducted under the immediate supervision of a director.

Financial aid in establishing the school was given by the Carnegie Corporation through a generous contribution of funds supplementary to those already made to the Society. Each year additional funds have been contributed by institutions at which sessions have been held, by professional engineering societies, industrial firms, foundations, and individuals, to all of whom acknowledgment is gratefully made.

Inception of the Summer School.—As stated above, the summer school is an outgrowth of the society's general investigation of engineering education. In the summer of 1925 W. E. Wickenden, Director of Investigation, who was then studying engineering education abroad, visited a somewhat similar summer school conducted by the British Board of Education. Upon his return to the United States he discussed the possibility of the establishment of a school directed to somewhat similar ends with the Associate Director of Investigation and suggested the advisability of the preparation of a tentative plan for the undertaking. At that time, the

Committee on Engineering Teaching Personnel—Dean Charles H. Warren of Yale University, Chairman, and Professor William H. Kenerson of Brown University, Secretary—was coöperating in studies of the status and problems of engineering teachers. The proposal for the establishment of the school was therefore first submitted to this committee. After consideration, the committee submitted a recommendation for the inception of the enterprise to the Board of Investigation and Coördination. The recommendation included a tentative outline of aims and methods and suggested that two sessions be held during the first year, one in the Middle West and one in the East, both to be devoted to the study of methods of teaching engineering mechanics, a key subject of the curriculum. The Board accepted this recommendation with the stipulation that the necessary funds and the coöperation of institutions at which sessions might be held be procured.

A more detailed plan for the operation of the schools was then prepared and submitted to President F. P. Keppel, of the Carnegie Corporation of New York. The favorable reaction of the Corporation was followed by a grant of funds needed for the first year. The plan was also submitted to the deans of engineering of Cornell University and of the University of Wisconsin who extended invitations to the Society to hold the sessions at their institutions. It was not until April of 1927 that these preliminary arrangements were completed. Announcement of the sessions was made about the middle of April and the work of recruiting staff members, arranging the programs, and other details was actively begun. Between April and June all arrangements were completed and the sessions were formally launched shortly before July 1, 1927.

It is perhaps appropriate to conclude this account of the inception of the Summer School by stating that the sessions of the first year, in spite of the experimental nature of the undertaking and the short time that was available for completion of the arrangements were considered by all who participated or observed to be successful beyond expectations.

Sessions of 1927–1933.—The following tabulation gives information concerning the locations, subjects, staff and member enrolments, and institutions represented in the twelve sessions of the first seven years.

SESSIONS OF THE SUMMER SCHOOL 1927–1933

Year	Subject	Place	Attendants		Number of Colleges Represented
			Members	Staff	
1927	Mechanics	Cornell University	41	17	36
1927	Mechanics	University of Wisconsin	41	20	32
1928	Physics	Massachusetts Institute of Technology	40	23	36
1928	Electrical Engineering	University of Pittsburgh (with the cooperation of the Westinghouse Electric Manufacturing Company)	52	45	45
1929	Mechanical Engineering	Purdue University (with the cooperation of the Western Electric Company)	90	49	53
1930	Engineering Drawing and Descriptive Geometry	Carnegie Institute of Technology	99	20	57
1930	Civil Engineering	Yale University	88	52	60
1931	Chemical Engineering	University of Michigan	69	34	47
1931	Mathematics	University of Minnesota	92	20	60
1932	Economics	Stevens Institute of Technology	40	37	22
1932	English	The Ohio State University	39	23	29
1933	Mining and Metallurgical Engineering	University of Wisconsin	30	36	24
	Totals		721	376	—

Objectives.—In planning any enterprise that was as much an innovation as the Summer School, it was necessary at the outset to prepare a definite statement of the objectives to which it was to be directed. Because of inherent differences in various branches of engineering study, it seemed likely that there might be minor modifications of the particular objectives of the various sessions, and that there might be important by-products in the effort to reach the general objectives sought. Throughout the undertaking, however, the aim has been the attainment of one principal purpose: the improvement of classroom teaching.

There are many elements that combine to that end, ranging all the way from a better understanding of the ultimate purposes of engineering education and from better mastery of the subject on the part of the teacher, to minor classroom devices and expedients. Many of these elements are such that they can be identified and studied; others are not. The first task in setting the objectives of the school, therefore, was to select those elements that appeared to be susceptible of analysis and discussion, within the limitations of the undertaking, and from among them to choose those that appeared to be of greatest importance. With these considerations in mind, the following specific aims of the Summer School were adopted:

> To bring about a better understanding of the fundamental laws of learning and of teaching.
>
> To establish the general principles that should underlie a sound teaching process.
>
> To determine the relative usefulness of the several kinds of teaching procedures and the conditions under which they might be combined to best advantage.
>
> In a given field, to select those elements of theory and practice that are of primary importance and of secondary importance, and, having established the essential core of principles, to study its organization into a course of instruction.
>
> To present something of the history of the subject in question in order to provide a background from which to teach it.
>
> To study the technique of teaching.
>
> To stimulate the teacher to self-improvement.
>
> To give a broader conception of engineering education and of the profession of engineering.
>
> To develop a scientific attitude toward teaching problems and to stimulate experiment and research.

Plan.—The plan of the summer school has been based upon the objectives just enumerated. Its principal features are as follows:

1. *Particular Subjects.* Each session of the school is devoted to a particular subject of instruction or to a related group of subjects. This feature of the plan, in addition to serving the major purpose of relating the work as closely as possible to the teacher's immediate problems, also serves other ends: It brings together groups of teachers having common problems who meet on a plane of common interests and ''talk the same language.'' It promotes an *esprit de corps* among them. It relates discussion of general principles of teaching to specific situations and problems and thus tends to test out generalities that might not otherwise be questioned.

2. *Different Institutions.* The various sessions of the school are held in different institutions throughout the country so as to make them as accessible as possible and to distribute whatever there may be of benefit or of burden among the various colleges.

3. *Methods.* The work of the sessions is conducted through formal lectures, demonstrations, and the like, and through informal discussions and seminars. The active participation of all of the members of the several groups is provided for. This is done partly through seminar or conference meetings and partly through the activities of groups of committees of members appointed to consider and report upon particular problems of instruction.

4. *Teaching vs. Subject Matter.* In all sessions emphasis is placed upon methods of teaching rather than upon subject matter. Some consideration of subject matter inevitably results, of course, since in engineering education as in other professional fields method and subject matter are so closely interwoven as to be inseparable.

5. *Informal Features.* All members of the group and of the staff are housed together for the duration of each session in order to give them ample opportunity not only to talk shop outside of the regular meeting hours, but to become well acquainted with one another.

6. *General Relationships.* In all sessions dealing with one of the major divisions of engineering, such as electrical engineering or mechanical engineering, a portion of the program is devoted to the relationship between the subject under consideration and professional or industrial practices. The staffs of most of the sessions therefore comprise not only teachers but engineers, scientists and industrial leaders.

7. *Advanced Studies.* A portion of each program is devoted to advanced phases of the subject under consideration, the purpose being to stimulate those in attendance to further study.

8. *Duration.* Sessions are of comparatively brief duration —generally three weeks each—but are intensive in nature.

9. *Academic Credit.* No academic credit is conferred for summer school attendance.

Program.—It was realized in planning the school that the programs of the various sessions should vary to some extent to accord with the nature of the division of the curriculum being considered. What might, for example, be an entirely appropriate set of topics for such a subject as mechanics would not be equally appropriate for engineering drawing. Certain features would be suitable for all programs, however, and there would be a common purpose underlying all.

As an illustration of the content and arrangement of a typical program, an outline of that of the Physics Session, held at the Massachusetts Institute of Technology, in 1928, is given below.

- Division I. General methods of teaching
  - Laws of learning
  - Principles and methods of teaching
  - Problems of student personnel
  - Examinations and tests
- Division II. Methods of teaching physics
  - As related to divisions of the subject: mechanics, heat, sound, etc.
  - As related to kinds of class exercises: lectures, recitations, laboratory periods, etc.
- Division III. Coördination with other divisions of the curriculum.

Subjects preparatory to physics
Subjects running concurrently
Division IV. History of physics
Division V. Advanced phases and applications of physics in engineering
Division VI. Lectures on topics of general interest, recreation, etc.

The relative time devoted to these divisions was about as follows: Teaching methods in general—one-sixth; methods of teaching physics—one-half; advanced physics and applications of physics—one-sixth; history, coördination with related subjects, general lectures, recreation and miscellaneous items—one-sixth.

An illustration of a complete program of one of the early sessions is given by that on engineering mechanics, held at Cornell University in 1927, which is printed in full in Appendix A.

A different arrangement of the program was provided for the sessions devoted to one of the major divisions (curricula) of engineering, as contrasted with that devoted to a single course. The program of the session on mechanical engineering, for example, was arranged in two principal parts:

Part I included those topics which are of concern to all teachers of mechanical engineering, including general principles of teaching, history of the subject, objectives of mechanical engineering courses, the mechanical engineering curriculum, methods of conducting laboratory work, and certain other topics.

Part II was arranged in three parallel divisions for teachers of the three principal sub-divisions of mechanical engineering: heat power, machine design and production. In these three sequences of divisional meetings emphasis was placed on specific problems of instruction relating directly to the particular division of the curriculum in question. In the heat power division, for example, teaching of the several subdivisions of thermodynamics were taken up in order. Attention was also directed to power plant design, furnace and boiler design, principles of combustion, and similar specific topics.

A day's schedule usually included one or two lecture periods devoted to general topics, followed by one or two periods for divisional meetings of the three groups mentioned. The complete program of the mechanical engineering session is printed in Appendix B.

Methods of Conducting the Sessions.—A number of experiments have been tried. Certain of the procedures have proved successful; others have not. In the early sessions, in addition to formal lectures, there were seminars, laboratory demonstrations, and a number of model teaching exercises in which members of the group demonstrated their methods of presenting a particular topic to a class. As experience with the sessions has accumulated, a larger portion of each program has been devoted to formal lectures and demonstrations, and less to the model class exercises. It was found that the atmosphere of the college classroom could scarcely be reproduced with a group of experienced teachers and that, while methods of instruction could be described and discussed, the effort to conduct model teaching exercises was largely a failure. The effort was then made to have the members of the group attend as observers at regular classes at that time in session in the institution. This plan met with some success, but the teacher visited testified that he found it difficult to conduct his classes in a normal way under those conditions.

Formal lectures have constituted the major portions of the programs throughout the life of the summer schools. These have been supplemented by demonstration of experiments, visits of inspection to laboratories in operation, informal discussion periods, and the still more informal, spontaneous group meetings where teaching is talked outside of the regularly scheduled hours.

Summer School Staffs. The staffs of the various sessions have all had certain features in common but have varied to some extent in accordance with the subject under consideration. Each staff has included a local director and a local secretary, selected from the faculty of the institution at which the session was held. The director, as the title implies, is in general charge of the session and acts as chairman of the teaching staff. The secretary assists the director, attends to details of housing and meals and acts as chairman of a committee who compile and write up the proceedings of the meetings. In addition to a director and a secretary, most of the staffs have an ''educational adviser,'' chosen from the faculty of a college of education, who lectures on the general educational principles and practices and serves as an advisory member of the staff on teaching problems. Each staff has also included a small nucleus of full-time members who serve throughout the sessions and, with the director and secretary, serve as a committee to decide questions concerning the conduct of the work as the sessions proceed. Associated with these members, each staff has included a considerable group of teachers, practicing engineers, scientists, and industrial leaders who lecture or conduct discussions on various aspects, technical or otherwise, of the subject under discussion.

It will be noted from the tabulation on page 5 that the staffs of the various ssesions have ranged in numbers from 17 to 52. This rather wide range results from differences in the nature of the subject and from the extent and nature of the program. Sessions devoted to a single course, such as mechanics or physics, have had smaller staffs than those devoted to a comprehensive division of the curriculum, such as mechanical engineering or civil engineering.

The staffs of the summer school have included many of the foremost teachers, scientists and engineers of the country. That of the civil engineering session, for example, included the president, the most recent past president and other officers and directors of the American Society of Civil Engineers; past presidents of the Society for the Promotion of Engineering Education; and a number of the most prominent teachers and practitioners of civil engineering. It is one of the most noteworthy features of the entire summer school undertaking that men of the caliber who have served have been willing to devote their time and energy so generously to it.

Enrolment and Rank of Attendants.—It was planned to limit the enrolment of the first sessions of the school to about thirty teachers with the idea of securing a small and homogeneous group and to promote intensive and intimate discussions. The number of applications far exceeded the original limit set, however, and forty was then fixed upon as the limit. At later sessions no prescribed limit of attendance has been set, enrolments having varied from a maximum of 99 to a minimum of 30. Enrolments have included the entire range of rank, age and teaching experience of American faculties. As an illustration, the session on mechanical engineering was attended by the following numbers of teachers of various ranks:

Deans	3
Professors	31
Associate Professors	14
Assistant Professors	13
Instructors	27
Other ranks	2
Total	90

At this session fifty-three different institutions in the United States and Canada and thirty-eight states and provinces were represented. In a word, the sessions have provided a representative cross-section of engineering faculties.

Financial.—As previously stated, the original appropriation for the school was made by the Carnegie Corporation of New York. A second appropriation and later a third and a fourth were made by the same foundation for the general expenses of the undertaking. Expenses of the individual sessions after the first year have been met through funds provided by a number of the institutions at which sessions have been held, certain of the professional engineering societies, interested individuals, and by three large industrial firms.

The teachers attending the sessions have been assessed a nominal registration fee of $10.

Staff members have in general received an honorarium or reimbursement of expenses.

The expenses of about half of the teachers who have attended have been paid in full or in part by the institutions which they represented. The other half have paid their own expenses in full.

A list of the contributors to the Summer School fund for the early sessions is given in acknowledgments in Volume I of these reports. The complete list of contributors for all the sessions is given in the Preface to Volume II.

Publications.—At the conclusion of the first sessions, in 1927, Bulletin No. 14, of the Investigation of Engineering Education, entitled "The Summer School for Engineering Teachers," was published. This bulletin gives a general summary of the summer school enterprise; its purpose, inception and plan; a condensed summary of the proceedings of the Cornell session and the Wisconsin session; and certain selected papers of the two sessions in full. It will be found in Vol. XXXV of the Society's "Proceedings," pp. 362 and 522, *et seq.*

Beginning with the sessions of 1928, a separate series of summer school publications was established. These are entitled "Selected Papers of the Summer School for Engineering teachers." Twenty-one numbers in this series have appeared. They include papers selected from among the various lectures and are generally of the following types:

Papers on educational principles
Papers on the history of the subject
Discussions of methods of teaching particular subjects of instruction
Papers on technical aspects of engineering practice.

A list of these publications is printed in Appendix C.

Results.—The writer, who has been closely identified with the work of the summer school since its inception, is perhaps not the person who should appraise its results. An excellent summary has been written by one of the members of the session of 1929. A portion of this article, which appeared originally in *Mechanical Engineering,* is quoted below. It is offered, in conclusion to this account of the Summer School enterprise, as a representative impression of one who attended and, it is hoped, as a fair appraisal of its results. Whether the Summer School is permanent or transitory remains to be seen, but in all accuracy it can be said that the enterprise has proved to be one of the truly stimulating factors that are contributing to the advancement of engineering teaching.

"WHAT DID THE SCHOOL ACCOMPLISH? *

"To evaluate adequately the benefits attributable to the summer school at Purdue is to attempt to give substance to a host of intangibles. Like the process of education, the experience will weigh differently with different men. It was a golden opportunity for the young instructor to absorb in countless ways a realization of the significance and importance of his profession and to benefit by numerous very definite additions to his knowledge of the subject matter he is teaching. He went away with an improved technique derived from specific suggestions made by the lecturers and by his observations of them and their methods. He saw the subjects he had been teaching presented in a new light. He heard problems discussed, the significance of which had never before appealed to him, and an enthusiasm to tackle them himself fired his ambitions. He met and talked with men whom he had read about, whose books he had studied, whose names had been heroic to him.

"The narrowness of sectionalism was dissipated in this meeting of men from all over the United States. The problems of teaching are largely similar, although local conditions may give them a different cast. And the local problems that arise in different social groups and sometimes affect major policies are more sympathetically understood after living three weeks with men representing so many of these groups.

"The schools to which these men return will benefit in more ways than one. The man comes back a better teacher, a broader individual. His outlook upon the problems of his school is more mature and less provincial. Fortunate indeed is engineering education in general which can number among its teachers so many who have benefited from the experience of the Summer School, and fortunate the college whose faculty contains several men so trained. An institution honestly trying to improve its methods and product will find that the slight expense involved in sending its instructors to one of these schools will be wonderfully fruitful. And yet, in spite of the obvious advantages to the school, more than half of the men who attended received no financial assistance from their institutions.

---

* From MECHANICAL ENGINEERING, September, 1929, page 711.

''The engineering societies are also beneficiaries in this program. To them falls the responsibility of fostering and giving direction to the efforts of engineers to help their profession. The profession is changing. Older men retire, or die, but younger men take their places in greater numbers. Most of these men come from the colleges. It is to the advantage of engineering societies, as it is to society at large, that these young men be of the highest type and have the best training that can be given. Their outlook upon life must be broad and sympathetic. They have it in their power to advance or to retard the progress of the industrial age—to brighten its luster or to bring it into discredit. Jealous of the record its members have made, the engineering societies have a very definite stake in the progress of engineering education. They could wish that all engineering teachers might be men to inspire the best and noblest ambitions and the broadest outlook upon life in the young men whom they teach.

''The stimulating experiences to which 90 deans, professors, and instructors of mechanical engineering were subjected at the S. P. E. E. Summer School for Engineering Teachers held at Purdue University from June 27 to July 18 are bound to have permanent and beneficial effects upon them and their profession. For three weeks the members of the Summer School lived and ate under the same roof and sat together in the classroom listening to lectures and taking part in discussions on the aims, content, and methods of teaching the subjects which comprise the mechanical engineering curriculum. They represented 60 educational institutions and came from 36 states and two of the Canadian provinces. As a cross-section of the profession of engineering teaching they made as typical a group as could have been brought together. The open-minded, earnest, and intelligent attention which they gave to making the most of an exceptional opportunity leads to the conviction that the return on any investment which they, their institutions, or the sponsors and staff of the school may have made will be a handsome one.

''Lectures and discussions made up the day's work at Purdue. A staff of lecturers, qualified by their exceptional attainments as educators and engineers, had been recruited from engineering colleges and the industries. The program was so rich in valuable material carefully planned to fit into a preconceived scheme that every morning and afternoon, and many evenings, were devoted to lectures, discussions, and committee meetings.

"Because mechanical engineering is a broad and inclusive field, it was decided to divide a portion of the program into three parts so that special emphasis could be placed upon three major branches of engineering subjects: heat power, machine design, and production. This plan provided smaller groups for the discussion of some of the more specific problems in these fields by men especially interested in teaching these subjects. The more general lectures and discussions were attended by all. The only disadvantage to the plan was that some very excellent lectures were given simultaneously, to the distress of those who wished to hear two or more speakers at the same hour. To have adopted a plan whereby every one might have heard every lecture, however, would have extended the length of the course unwisely.

Some Impressions

"The impressions which are made by such an experience as this one at Purdue will vary with the individual and are not always easy to transmit. The present reviewer, therefore, records some of his own interpretations of the more general themes which dominated, in his mind, the spirit of the papers and discussions.

"There was, first of all, a reassuring conviction that teachers of engineering are on the right track. In an age of sudden changes and in a new environment, both attributable in a large degree to the impress of the engineer upon civilization, methods and purposes of education have undergone change also. While some have failed to recognize this fact, while others have been stampeded into ill-advised programs of specialty training, engineering teachers have been able to maintain a conservative balance with a progressive vision. What is more significant, they have, and in this they are unique, boldly questioned their aims, ideals, and methods, with a hope, which has been realized in part at least, of improving themselves, their schools, and their product. No other group of teachers, it may be confidently said, has done this in as thorough a manner, and no other group of teachers has formulated so definitely its ideas on these essential points. Colleges of liberal arts, offering varied programs of studies, have never given such strict attention to the result they hope to accomplish or the means by which it is to be accomplished, because their objectives lack the definiteness which gives form to the engineering curriculum and the educational needs of the graduate engineer.''

APPENDIX A

Summer School for Engineering Teachers

PROGRAM OF SESSION ON MECHANICS

Cornell University, July 6–26, 1927

Wednesday, July 6

10:00 A.M. Address of Welcome ....Dexter S. Kimball
The Purposes and Aims of the Summer School for Engineering Teachers ....H. P. Hammond
Organization of the Group—Appointment of Committees, etc.
2:00 P.M. The Place of the Study of Mechanics in the Engineering Curriculum ....D. S. Kimball
3:00 P.M. Outline of the Plan and Program of the Summer School J. E. Boyd
Discussion.

Thursday, July 7

9:00 A.M. to 11:30 A.M. (with intermission). The Teaching of the Fundamentals of Mechanics ...W. S. Franklin
2:00 P.M. Group Seminars for discussion of the topic of the morning session
W. S. Franklin, J. E. Boyd, E. W. Rettger

Friday, July 8

9:00 A.M. The History of Mechanics before Newton ..E. W. Rettger
10:30 A.M. Teaching the Fundamentals of Mechanics. W. S. Franklin
2:00 P.M. Project Assignment: Preparation of Directions for Laboratory Exercises in Mechanics.
W. S. Franklin, J. E. Boyd, E. W. Rettger

Saturday, July 9

9:00 A.M. to Noon. Application of Mechanics in Electrical Engineering ....Vladimir Karapetoff
P.M. Recreation.

Monday, July 11

9:00 A.M. Equilibrium of Concurrent Co-Planar Forces ..J. E. Boyd
10:30 A.M. The History of Mechanics: Newton and His Successors ....E. W. Rettger
2:00 P.M. Project Assignment: Devising Problems in Statics.
W. S. Franklin, J. E. Boyd, E. W. Rettger

Tuesday, July 12

9:00 A.M. Equilibrium of Non-Concurrent Co-Planar Forces. J. E. Boyd

10:30 A.M. A Method of Conducting Class Work ......E. W. Rettger

2:00 P.M. Methods of Conducting Undergraduate Classes in Mechanics. S. G. George, W. R. Cornell and K. D. Wood

3:00 P.M. Demonstration of Teaching Methods by Members of the Conference.

Wednesday, July 13

9:30 A.M. to Noon. The Materials Testing Course at Cornell University ....G. B. Upton

P.M. Recreation.

Thursday, July 14

9:00 A.M. Center of Gravity and Moment of Inertia .....J. E. Boyd

10:00 A.M. Work and Energy ....E. W. Rettger

2:00 P.M. Project Assignment: Preparation of a Set of Directions for a Laboratory Exercise. J. E. Boyd, W. S. Franklin, E. W. Rettger

Friday, July 15

9:00 A.M. Couples ....E. W. Rettger

10:30 A.M. Some Teaching Problems Affecting Engineering Teachers ....R. M. Stewart

2:00 P.M. Model Presentations and Group Discussions of Methods of Conducting Classes in Mechanics.

Saturday, July 16

9:00 A.M. to Noon. Problems of Elasticity in Mechanical Design ....S. Timoshenko

P.M. Recreation.

Monday, July 18

9:00 A.M. Dynamics of Rotation ....W. S. Franklin

10:30 A.M. Experimental Verification of Column Formulas. J. E. Boyd

2:00 P.M. Group Seminars. J. E. Boyd, W. S. Franklin, E. W. Rettger

Tuesday, July 19

9:00 A.M. Simple Beams ....E. W. Rettger

10:00 A.M. Statics of Connected Bodies ....J. E. Boyd

2:00 P.M. Project Assignment: Preparation of Examinations. E. W. Rettger, J. E. Boyd, W. S. Franklin

WEDNESDAY, JULY 20

9:00 A.M. to Noon. Hydromechanics .... C. M. Allen
Discussion.
P.M. Recreation.

THURSDAY, JULY 21

9:00 A.M. Fixed and Continuous Beams .... E. W. Rettger
10:30 A.M. Examples of Mechanical Wave Motion ... W. S. Franklin
2:00 P.M. Symposium on Teaching Methods.

FRIDAY, JULY 22

9:00 A.M. Examples of Mechanical Wave Motion .... W. S. Franklin
10:00 A.M. Symposium on Self-Improvement of the Teacher.
2:00 P.M. Symposium on Improvement of Teaching.

SATURDAY, JULY 23

9:00 A.M. to Noon. Structural Mechanics .... M. S. Ketchum
P.M. Recreation.

MONDAY, JULY 25

9:00 A.M. The Use of Mechanical Ideas in Electricity.
W. S. Franklin
10:30 A.M. Dynamics of Connected Bodies .... J. E. Boyd
2:00 P.M. Project Assignment: Design of Simple Apparatus
for Use in Illustrating Principles of Mechanics.

TUESDAY, JULY 26

8:00 A.M. The Gyroscope .... W. S. Franklin
9:00 A.M. Moments and Deflections of Closed Rings .... J. E. Boyd
12:00 Noon Adjournment.

EVENING MEETINGS

Tuesday, July 5. Smoker
Tuesday, July 12. Lecture: The Engineer and Public Relations. L. W. Wallace, Executive Secretary, American Engineering Council
Thursday, July 14. Lecture: The Importance of the Unpractical. John C. Parker, Vice President, Brooklyn Edison Company.
Friday, July 15. Lecture: Opportunities for Teachers of Mechanics. Charles F. Scott, Chairman, Board of Investigation and Coordination, S. P. E. E.
Recital on Cello and Piano. Vladimir Karapetoff.
Monday, July 18. Lecture: Engineering Education and the Social Order. W. E. Wickenden, Director of Investigation, S. P. E. E.

Friday, July 22. Lecture: University Development in Europe and the United States. Parke R. Kolbe, President, The Polytechnic Institute of Brooklyn.

Saturday, July 23. Subscription Dinner. Professor Emeritus Irving P. Church, guest of honor.

Monday, July 25. Lecture: What the College Has done for the Engineering Graduate. R. E. Doherty, Consulting Engineer, General Electric Company.

APPENDIX B

PROGRAM OF SESSION ON MECHANICAL ENGINEERING

PURDUE UNIVERSITY, JUNE 27–JULY 18, 1929

WEDNESDAY, JUNE 26

P.M. Registration.

THURSDAY, JUNE 27

8:00 A.M. Registration.
9:00 A.M. Opening Session; Dean A. A. Potter presiding.
Remarks and Announcements ....H. P. Hammond
Present Trends in Higher Education ....Edward C. Elliott
Aims and Purposes of Mechanical Engineering Education
D. S. Kimball
1:15 P.M. Purposes and Scope of Courses in Heat Engineering
A. A. Potter
2:45 P.M. Inspection of Purdue University Engineering Laboratories ....G. A. Young
7:30 P.M. Smoker

FRIDAY, JUNE 28

8:30 A.M. Purposes and Scope of Courses in Mechanism and Machine Design ....O. A. Leutwiler
10:15 A.M. Psychology of the Learning Process ....C. H. Judd
1:15 P.M. Purposes and Scope of Courses in Production Engineering ....D. S. Kimball
2:45 P.M. The History of Mechanical Engineering .William D. Ennis
7:30 P.M. Round Table Discussion led by ....C. H. Judd
Topics: Specificity vs. Generalization in Learning
Teaching the Student How to Study

SATURDAY, JUNE 29

8:30 A.M. College Personnel Methods ....A. A. Potter
10:15 A.M. General Principles of Teaching ....C. H. Judd

11:30 A.M. Appointment and Organization Meetings of Committees
1:30 P.M. Trip to Turkey Run State Park
Address: The Services of the Engineer in the Development of the Public Estate ....Richard Lieber

MONDAY, JULY 1

8:30 A.M. How to Conduct Lectures and Recitations .....C. H. Judd
10:15 A.M. Symposium on Methods of Teaching, Led by C. H. Judd and G. W. Munro
1:15 P.M. Divisional Meetings:

Heat Power	*Machine Design*	*Production*
Thermodynamics; Principles and Definitions Properties of Gases G. W. Munro	Analysis of Motion R. C. H. Heck	Content of Courses in Industrial Administration D. S. Kimball
2:45 P.M. Gas Cycles F. O. Ellenwood	Classroom Methods in Machine Drawing and Machine Design O. A. Leutwiler	Purposes and Scope of Shop Courses O. W. Boston

TUESDAY, JULY 2

8:30 A.M. Factors Influencing the Cost of Power ...C. F. Hirshfeld
10:15 A.M. Financing Manufacturing Enterprises ...G. M. Williams
1:15 P.M. Teaching Values and Costs to Engineering Students ....D. S. Kimball
2:45 P.M. Symposium on the Teaching of Values and Costs, Led by ....D. S. Kimball and A. A. Potter

WEDNESDAY, JULY 3

8:30 A.M. Divisional Meetings:

Heat Power	*Machine Design*	*Production*
Properties of Vapors G. W. Munro	Transmission of Motion R. C. H. Heck	Manufacturing Methods in Production E. Gruenwald
10:15 A.M. Vapor Cycles F. O. Ellenwood	Machine Parts O. A. Leutwiler	Content of Shop Courses O. W. Boston
1:15 P.M. Flow of Fluids F. O. Ellenwood	Kinematic Principles in Machine Design R. C. H. Heck	Distribution F. C. Hockema

2:45 P.M. Steam Prime Movers ....C. F. Hirshfeld
7:30 P.M. Trends in Power Plant Development in the United States and Europe ....C. F. Hirshfeld

Thursday, July 4

Picnic at Ross Camp

Friday, July 5

8:30 A.M. The Fundamentals of Management Applied to Industrial Enterprises ....L. P. Alford
10:15 A.M. Fuels and Combustion ....W. J. Wohlenberg
1:15 P.M. Divisional Meetings:

Heat Power	*Machine Design*	*Production*
Heat Reaction in the Boiler Furnace W. J. Wohlenberg	Machine Parts O. A. Leutwiler	Organization for Executive Control L. P. Alford

2:45 P.M. Applications of Mechanics to Machine Design O. A. Leutwiler
6:00 P.M. Dinner Meeting. Management's Responsibility for Labor Administration in Industry and Its Relation to Engineering Education ...Sam A. Lewisohn

Saturday, July 6

8:30 A.M. Materials in Machine Construction ....H. F. Moore
10:15 A.M. Divisional Meetings:

Heat Power	*Machine Design*	*Production*
Economics of Heat Transfer W. J. Wohlenberg	Teaching of Materials in Machine Design H. F. Moore	Organization for Production Control L. P. Alford

Monday, July 8

8:30 A.M. Purposes and Scope of Mechanical Engineering Laboratory Courses ....G. A. Young
10:15 A.M. Divisional Meetings:

Heat Power	*Machine Design*	*Production*
Steam Generating Equipment C. H. Berry	Principles of the Design of Machine Tools E. A. Muller	Plant Layout and Design J. W. Roe
1:15 P.M.		
Steam Power Auxiliaries C. H. Berry	Design of Machine Tools; Details E. A. Muller	Power Requirements J. W. Roe

2:45 P.M. Methods of Mechanical Engineering Laboratory Courses (with demonstrations)
G. A. Young, G. W. Munro, F. C. Hockema, H. L. Solberg
7:30 P.M. Symposium. The Influence of Standardization on the Mechanical Industries Couducted under the Auspices of the A.S.M.E. Standardization Committee.

TUESDAY, JULY 9

8:30 A.M. The Teaching of the Principles of Automotive Engine Design ....C. B. Veal
10:15 A.M. Metering in Power Plants ....E. G. Bailey
1:15 P.M. Internal Combustion Engine Design ....H. A. Huebotter
2:45 P.M. Divisional Meetings:

Heat Power	*Machine Design*	*Production*
Steam Generating Equipment Design E. G. Bailey	Steam Generating Equipment Design E. G. Bailey	Job Standardization J. W. Roe

WEDNESDAY, JULY 10

AT HAWTHORNE WORKS OF WESTERN ELECTRIC COMPANY

9:00 A.M. Organization Plan of the Hawthorne Works ..C. L. Rice
9:45 A.M. General Description of the Hawthorne Physical Plant and Product ....G. A. Pennock
10:30 A.M. Principles of Production Control ....C. G. Stoll
11:15 A.M. Production Control as Applied to a Selected Unit of Product; Part I (with demonstrations in the lecture room) ....G. A. Landry
12:30 P.M. Lunch
1:30 P.M. Inspection of manufacturing processes, illustrating the lectures of the morning.

THURSDAY, JULY 11

AT HAWTHORNE WORKS OF WESTERN ELECTRIC COMPANY

9:00 A.M. Purchasing Policies ....J. W. Bancker
9:45 A.M. Materials: Purchasing, Handling and Storage Methods ....E. M. Hicok
10:45 A.M. Inspection and Testing of Materials and of Product ....C. W. Robbins
11:30 A.M. Description of Production Control as Applied to One Selected Unit of Product; Part II
J. M. Stahr
12:30 P.M. Lunch

1:30 P.M. Inspection of Manufacturing and Materials Processes, illustrating the lectures of the morning (with special reference to special machines and tools)

7:30 P.M. Basic Principles of Personnel Administration
F. W. Willard

Personnel Organization and Practices of the Hawthorne Works .... H. C. Beal

Recruitment and Development of Engineering College Graduates in the Bell System .... R. I. Rees

Friday, July 12

At Hawthorne Works of Western Electric Company

9:00 A.M. Cost Control Methods .... J. M. Stahr

10:00 A.M. The Uses of the Product of the Hawthorne Works
W. O. Kurtz

10:45 A.M. Manufacturing Development .... S. Bracken

11:45 A.M. Development of Wire Drawing Methods ..... J. R. Shea

12:30 P.M. Lunch

1:30 P.M. Inspection of Wire Drawing and Cable Manufacturing Plant

Saturday, July 13

8:30 A.M. Reports of Committees:
Pre-requisites
Inspection Trips

10:00 A.M. The Industrial Revolution .... J. W. Roe

11:00 A.M. Variables of Teaching in Technical Schools
Edward C. Elliott

Monday, July 15

8:30 A.M. Recent Developments in the Application of Mechanics to Machine Design .... S. Timoshenko

10:15 A.M. Administration of Mechanical Engineering Shop Laboratories .... Edward F. Miller

11:15 A.M. Trends in Design of Prime Movers ...... F. Hodgkinson

1:15 P.M. Training of Designers:
Qualities They Should Possess .... F. Hodgkinson
Methods of Training .... S. W. Dudley

2:30 P.M. Divisional Meetings:

Heat Power	*Machine Design*	*Production*
The Teaching of Heating, Ventilation and Refrigeration Edward F. Miller	Balancing S. Timoshenko	Economics of Tools and Equipment J. W. Roe

7:30 P.M. Organization and Administration of Mechanical Engineering Departments ....Edward F. Miller

Tuesday, July 16

8:30 A.M. Modern Methods of Stress Analysis ......S. Timoshenko
10:15 A.M. Organization of Courses in Mechanical Engineering Subjects for Non-Mechanical Engineering Students ..S. W. Dudley and Edward F. Miller
11:15 A.M. Research in Mechanical Engineering ....A. A. Potter
1:15 P.M. General Session on Mechanical Engineering Laboratory Courses, including Report Writing
Edward F. Miller, S. W. Dudley, G. A. Young, H. L. Solberg
2:45 P.M. Mechanical Laboratory Test Demonstrations .G. A. Young
7:30 P.M. The Work of James Watt and Its Influence ..I. N. Hollis

Wednesday, July 17

8:30 A.M. Reports of Committees: (Divisional Meetings)

Heat Power	*Machine Design*	*Production*
Heat Power Courses for Non-mechanical Engineers	Purposes and Methods of Design Courses	Aims and Methods of Shop Courses

10:00 A.M. Fundamental Principles of Material Handling, Their Effect upon Industrial Plants and Economic Production ....Harold V. Coes
11:00 A.M. Committee Reports:
Values and Costs
Teaching of Management Courses
1:15 P.M. Reports of Committee: Laboratory Instruction
2:30 P.M. The Contribution of Willard Gibbs to Thermodynamics ....John Johnston
6:00 P.M. Dinner Meeting. Speakers:
David E. Ross, John Johnston, W. E. Wickenden

Thursday, July 18

8:30 A.M. Report of Committee: The Teaching of Personnel Administration
9:15 A.M. Mechanical Engineering Problems in Aviation
Edward P. Warner
10:30 A.M. Personal Elements of Efficient Instruction
Edward C. Elliott
11:30 A.M. Report of General Committees
12:00 M. Adjournment

APPENDIX C

SELECTED PAPERS OF THE SUMMER SCHOOL FOR ENGINEERING TEACHERS

No. 1. Our Debt to the Electricians of the Nineteenth Century. By Henry Crew. (Physics Session, 1928.)
No. 2. Historical Outline of the Electrical Units. By A. E. Kennelly. (Electrical Engineering Session, 1928.)
No. 3. Reports of Committees of the 1928 Sessions. (Physics, Electrical Engineering.)
No. 4. Collected Papers of the Physics Session. (1928.)
No. 5. Collected Papers of the Electrical Engineering Session. (1928.)
No. 6. A Resumé of Mechanical Engineering Since James Watt. By William D. Ennis. The Industrial Revolution. By Joseph W. Roe. James Watt. By Ira O. Hollis. (Mechanical Engineering Session, 1929.)
No. 7. Reports of Committees of the Mechanical Engineering Session. (1929.)
No. 8. Papers of the General Division of the Mechanical Engineering Session. (1929.)
No. 9. Papers of the Heat Power Division of the Mechanical Engineering Session. (1929.)
No. 10. Reprints of Papers published by the American Society of Mechanical Engineers. (Mechanical Engineering Session, 1929.)
No. 11. Papers of the Machine Design Division of the Mechanical Engineering Session. (1929.)
No. 12. Papers of the Production Division of the Mechanical Engineering Session. (1929.)
No. 13. The Enrichment of Experience in the Development of the Teacher. By John C. Tracy. (Civil Engineering Session, 1930.)
No. 14. Three Lectures on Learning and Teaching. By Francis T. Spaulding. (Civil Engineering Session, 1930.)
No. 15. Historical Papers of the Sessions on Civil Engineering and on Descriptive Geometry and Engineering Drawing. (1930.)
No. 16. Miscellaneous Papers of the Engineering Drawing and Descriptive Geometry and the Civil Engineering Sessions. (1930.)

No. 17. Reprints of Papers Published by the American Society of Civil Engineers. (Civil Engineering Session, 1930.)
No. 18. Outline of the History of Mathematics. By R. C. Archibald. (Mathematics Session, 1931.)
No. 19. Four Papers on the Teaching of Mathematics. (Mathematics Session, 1931.)
No. 20. Collected Papers of the Session on English. (1932.)
No. 21. Collected Papers of the Session on Mining and Metallurgical Engineering. (1933.)

In addition to the Selected Papers of the Summer School, as listed above, Bulletin Number 14 of the Investigation of Engineering Education may be consulted for a complete account of the Sessions on Mechanics, of 1927. See Footnote, page 1117. See also Publications of the Board, (c) Summer Schools, page 1282, and Bibliography, pages 1290, 1299.

CONFERENCE OF ADMINISTRATIVE OFFICERS OF ENGINEERING COLLEGES, MADISON, WISCONSIN, JULY 3–7, 1933

REPORT OF THE COMMITTEE *

A Conference of Administrative Officers of Engineering Colleges was held at Madison, Wisconsin, during the week following Engineers' Week in Chicago, a feature of the Century of Progress Exposition, at which time the Society for the Promotion of Engineering Education celebrated the fortieth anniversary of its founding.

The conference was called for the consideration of problems and policies relating to the administrative phases of engineering education. It was suggested by the Associate Director of Investigation and Director of Summer Schools who had noted in visits to engineering colleges and in conferences with their officers that there were numerous problems and questions of administrative character which were common to many institutions. The suggestion met with the endorsement of those with whom it was discussed. The year 1933 seemed opportune for such a conference: At that time engineering education was beginning to be affected to the full by the economic and industrial depression; colleges were faced with problems of the most serious nature; many grave issues were demanding attention, not only from the standpoint of immediate urgency, but also from that of long range planning. It seemed highly desirable to afford apportunity for the consideration of these major issues under circumstances such that discussion and exchange of ideas might be thorough, free and intimate. The conference plan, inaugurated by the Board at a previous meeting held at Washington, in November, 1926, for receiving and discussing the preliminary report of the

---

* Arrangements for the Conference were delegated by the Board to a special committee comprising Charles F. Scott, Chairman, F. L. Bishop, and H. P. Hammond.

Board covering the first stages of the Society's investigation of engineering education,* promised to afford such opportunity. It was accordingly adopted. A tentative outline of the general plan of such a conference was then presented to the administrative officers of a number of the larger engineering colleges. The general plan, together with the proposed time and place were endorsed. The Board then placed the project in charge of a special committee, which, in conference with the members of the Board, arranged the program, selected the speakers, and provided for the conduct of the meetings.

The conference was held at the University of Wisconsin, which acted as host. Dean Frederick E. Turneaure and Professor Ben. G. Elliott served as a local committee in charge of arrangements for housing accommodations, meeting place and other details. The guests and their families were housed in Tripp Hall, a dormitory situated on the shore of Lake Mendota.

ATTENDANCE, PROGRAM AND PUBLICATIONS

Attendance was by invitation, extended to administrative officers of all the engineering schools of the country, and comprised 6 presidents, 52 deans, 30 heads of engineering departments and 7 other individuals. The attendance was widely representative of various types of institutions and sections of the country; 33 states and 64 colleges and universities, as well as 6 other organizations being represented.

The program of the conference, which is printed in full in the Appendix, began with consideration of immediate problems arising out of economic and industrial conditions, and proceeded from the more concrete problems of immediate urgency to those of longer range importance—the major policies of engineering education. All portions of the program related primarily to administrative functions and were chosen so as not to conflict with consideration of those educational problems which should properly be dealt with at the Society's regular conventions. While a regular program with assigned topics and with appropriate and distinguished speakers was arranged, it was anticipated that the speakers would present their subjects briefly as introductions to general, roundtable discussions, which should constitute the major feature of the session.

---

* See ''Proceedings,'' Society for the Promotion of Engineering Education, 1926, Vol. XXXIV, pages 529–541.

The program began with an analysis of the situation surrounding engineering education and with consideration of the financial outlook for higher education in the next decade. Following this introduction there was consideration of administrative problems emphasized by the emergency situation; the selection and development of faculties; engineering education in the light of changed economic and industrial conditions; methods of aiding students affected by the depression; the situation as to engineering graduates and educational opportunities for such of them as are unemployed; the problem of the relationship of junior colleges to engineering education; professional licensure and its effects; and the recognition of engineering colleges by public and other agencies. One session was reserved for consideration of topics suggested by those in attendance, and much free time was provided for conferences and informal gatherings in small groups for discussion of problems of mutual concern and interest.

A general summary of the papers, discussions, and results of the conference, written by George A. Stetson, member of the Society's Council, and editor of the publications of the American Society of Mechanical Engineers, will be found in the JOURNAL OF ENGINEERING EDUCATION for September, 1933, and certain of the papers will also be found in full in the JOURNAL for October, 1933, and for February, 1934.* The following abridged summary of the proceedings is a condensation of Mr. Stetson's report.

OPENING OF THE CONFERENCE

Charles F. Scott, Yale University, presiding at the opening session in his capacity as Chairman of the Board of Investigation and Coördination, opened the conference with a brief introduction in which he first pointed to the coincidence between our economic depressions and various chapters in the history of engineering education: The Morrill Act and the Civil War period; the panic of 1873 and the decade of great expansion in the numbers of engineering schools; the depression of the 90's and the organization of the Society for the Promotion of Engineering Education; the depression of 1907 and the inauguration of steps which culminated in the Mann investigation and report; the depression of 1921 and the establishment of the Board which later undertook its comprehensive studies; and, finally, the present depression as a result of which, in part, the Conference of Administrative Officers had been called. He spoke of the conference as a logical outgrowth of the underlying idea of the Society's Summer School for Engineering Teachers, the general conception and methods of which had been largely followed in planning the present meeting.

---

* For list of papers printed in the JOURNAL OF ENGINEERING EDUCATION, see Program in the Appendix to this Report, page 1161. Papers are listed in the Bibliography.

Informality and freedom of discussion was to be the keynote of the meeting. The program was flexible, affording ample time for the discussion of scheduled topics and others that might be proposed. Ample provision had also been made for informal gatherings in small groups and for "walks and talks by the wayside." "The story of engineering education in the past," he said, "has been one of readjustment to the changing environment of a changing civilization. The lamp of experience indicates no clear, smooth road in the future. Fortunate are we if we can discover its general trend and prepare our engineering graduates to go that way."

In conclusion, Chairman Scott quoted from recent remarks by President Glenn Frank, University of Wisconsin: " 'We are at a dangerous moment. We shall pay for it if we give up our faith in the engineering mind.' And to-day administrators of engineering schools—men of engineering mind—have assembled to apply that engineering mind to their own problem, that of supplying facilities and policies with which the productive agencies of engineering colleges—the faculties and students—may function to produce engineers for the coming decades."

THE PRESENT STATUS

The scheduled program of the conference opened with a symposium, led by Harry S. Rogers, Oregon State Agricultural College, on the general status of engineering education to-day, with emphasis on finances, enrolments, budgets, salaries and other matters of immediate, though not necessarily transient, concern. Others participating in the symposium, and representing various sections of the country, were Robert L. Sackett, Pennsylvania State College, H. S. Evans, University of Colorado, Willard E. Hotchkiss, Armour Institute of Technology, and Blake R. VanLeer, University of Florida. The symposium furnished a comprehensive picture of conditions prevailing throughout the engineering colleges of the country. Major conditions noted included a strong tendency toward consolidations and eliminations, both as to institutions, departments, curricula and courses of study. There was some tendency to lower admission barriers and to increase tuition fees. Undergraduate enrolments had dropped throughout the country as a whole, particularly in the freshman year; graduate enrolments had shown a sharp rise. Teaching loads and sizes of class sections had been increased. Additions to physical facilities had been virtually suspended. Budgets had been seriously cut, with the exception of very few institutions. Research had been seriously cut, as had extension work. One of the most serious consequences of present conditions was the abbreviated school year in effect in several sections of the country in primary and secondary schools. This, in the course of the next few years, would be the cause of many students applying for admission with less than normal preparation, a situation which the colleges would find it necessary to face. On the other side of the picture, many unnecessary duplications of efforts and of facilities were in process of elimination, student morale had improved, and a general spirit of earnestness and seriousness above the ordinary prevailed on many campuses.

The Outlook for the Future

Charles R. Mann, American Council on Education, speaking on the topic ''Financial Outlook for Higher Education During the Next Decade,'' dealt essentially with the challenge to education caused by the present situation. Dr. Mann stated that it would depend on how well the people recognized that educational institutions contributed to the general welfare as to what support might be expected. The cost of higher education, viewed as a national expense, was small, being one half of one per cent of the national income in 1929. At present it was not more than one per cent of the national income. There are many evidences, however, of drastic efforts to reduce expenditures far below their present amount. Dr. Mann discussed activities of citizens' councils looking into community expenditures, and stated that the grants to educational institutions would depend upon the conclusions of such bodies as to the relative values of education in comparison with other civic activities. He referred to the Wisconsin idea of coöperating with the state as something that might be considered in other states to-day. Dr. Mann then suggested that the radical changes in the basic relationships between government and business, embodied in the National Industrial Recovery Act, provided a field in which educational institutions could exert a constructive influence. If schools met the present challenge effectively, he concluded, the people will be spending a great deal more than one half of one per cent of the national income on higher education ten years from now.

Budgeting and Finance

O. M. Leland, University of Minnesota, presented the subject of budgeting and finance, particularly in the light of present emergency situations caused by restricted income. He listed the order in which retrenchments may be undertaken so as to conserve the essential activities of a college of engineering while meeting the necessities of the situation, grouping the principles in accordance with which they should be made in the following order:

1. Essential activities, units and organizations must be preserved. Permanent crippling must be avoided.
2. Partial suspension may be possible without permanent loss.
3. A plan for gradual recovery should be mapped out.
4. The basic set-up for research and service as well as the indispensable instruction should be retained.
5. Economies may be effected in small items aggregating considerable sums.
6. Adjustments may be desirable, such as reduction of enrolment by more selective admissions, increased size of class sections, greater teaching loads, omission of less essential elective courses.
7. Administrative re-adjustments, such as combinations of colleges or departments, abandonment of departments which are no longer necessary, grouping of services in centralized units, use of part-time employees among several departments.

Selection and Development of Faculties

Much attention was devoted throughout the conference to matters relating to faculty administration, selection and development. The subject was introduced by J. W. Barker, Columbia University, who listed first the qualities desirable in permanent staff members and capacities which should be looked for in juniors. Good teachers, he said, were the product of much labor by their seniors. He approved the group conference for those teaching the same or related subjects, and the practice of assisting younger teachers by visits to their classrooms. Dealing with the development of younger teachers, he advocated the practice of limiting the term of service of instructors appointed from among the graduates of the preceding year to two or three years, this to be followed by practical experience elsewhere, supplemented by teaching experience, before reappointment to permanent posts.

Dean Barker believed it wise to have junior staff members represented on faculty committees and to discuss administrative matters, at times, in their presence.

Dexter S. Kimball, Cornell University, continuing the discussion of faculty and institutional administration, said that while universities involved a great deal of administration, he believed that faculties should participate more fully in formulation of aims and policies, particularly those relating essentially to fundamental educational policy. While boards of trustees are necessary under the present conditions and form of university organization, it was difficult, he believed, for such groups to appraise many of the factors that arose in administration, and hence they should consult more freely with faculties. It would be desirable, in fact, to have the faculty represented on the board of trustees.

Turning to the matter of internal faculty and college organization, he advocated a plan of weekly conferences of deans as a device for bringing about harmony of policies and aims. He also advocated the plan of a committee on university policy to deal with such problems as the recruitment of the faculty, its maintenance at a high standard of excellence, tenure of office and student relations.

Personnel Problems

Edward C. Elliott, Purdue University, opened the discussion of the problem of aiding students affected by the depression. It was our duty, he said, to make the students aware that the country is passing from one epoch into another. In such circumstances it was imperative to develop the morale of the student body; a sense of self-responsibility should be developed. He felt we should be honest with our students, present and prospective; they should be advised not to enter college unless they have sufficient funds. Care should be taken not to add to the human scrap-heap outside our doors; students should not be led into blind alleys. Practical methods of help lay in reduction of fees and costs. ''Busy work'' for graduates out of jobs would be of help to them. President Elliott concluded his remarks by saying that engineering colleges should make sure of their process of recruitment in order to protect the future of the profession.

Paul Cloke, University of Maine, continuing the discussion of personnel matters presented the situation surrounding engineering graduates. He cited data indicating that the percentage of recent graduates in medicine that had been placed in professional positions exceeded that in other professions. He felt that emphasis upon quality of the product of medical schools had reacted favorably in this respect. In his opinion, the law of supply and demand would operate to decrease the number of students entering engineering schools. He believed that recent graduates would, in many instances, displace older men who had been laid off temporarily, thus causing a problem that it would be difficult for engineering colleges to influence.

J. W. Barker, Columbia University, discussed the problem of assisting unemployed engineeering graduates, citing measures undertaken in New York City by Columbia University in coöperation with the Professional Engineers' Committee on Unemployment. At Columbia unemployed graduates having the necessary qualifications were permitted to register for certain classes up to the limit of classroom seats. No credit was conferred for the work. Laboratory courses were not included. Classes for graduates were also conducted in the Engineering Societies Building under the auspices of Engineering Foundation. Both of the measures of assistance described were successful in their operation.

GRADUATE WORK

Dugald C. Jackson, Massachusetts Institute of Technology, dealt with the function of administrative officers with reference to graduate work, and said that teachers who direct such work must have sufficient respite from the execution of conventional details so that they might give productive contemplation to each individual student's qualities and ambitions, as well as to the advancement of knowledge in the field.

''The administrative duties which have reference to graduate work,'' he said, ''are first to understand the needs of the work, then to secure and maintain an appropriate staff, and finally to provide the staff with facilities and encouragement. The conventional heavy allotment of specifically assigned teaching hours is a preventive of the best originality and resourcefulness in undergraduate instruction. It is wholly out of keeping with making an inspiring success in graduate instruction. The administrative problems of staff related to the topic simmer down to securing men of suitable intellectual qualities, encouraging their ambitions, and limiting their assigned specific teaching hours. In my opinion, no engineering school is justified in advertising that it undertakes graduate instruction unless it has one or more men in staff who have a real mastery of some division of engineering and who can be protected from an excessive number of assigned conventional hours in classroom and laboratories. It is also desirable that the institution should possess departments of science, especially mathematics, physics, and chemistry, which are equally alive.''

Junior Colleges

George F. Zook, United States Commissioner of Education, presented the subject of junior colleges and their relation to engineering schools. Dr. Zook regarded the junior college movement as one of the new ideas in educational organization which demanded the careful consideration of all those concerned with our educational system.

Two underlying factors in the situation relating to junior colleges were presented for consideration: ''The first of these is the simple fact that through the establishment of junior college facilities in increasing numbers throughout the country a larger and larger proportion of the population is able to secure the advantages of two years of education beyond the high school at a minimum of cost.'' This has led, universally, to a larger proportion of young people availing themselves of such education than would have been the case had they been required to go outside of their local communities for college work.

''The second consideration is educational. Historically the elementary school and the college in this country were founded about contemporaneously . . . the secondary school, which was later inserted between these two crystallizing units of education, found itself occupying a restricted and uncertain area of four years of education. To find itself, as it has done in Europe, it has been compelled to elbow the elementary school on the one hand and the undergraduate college on the other. In many school systems it has seized the latter two years of the eight-year elementary school and has organized a new unit known as the junior high school. In somewhat the same way it is reaching for the first two years in college.''

Dr. Zook set forth briefly the function of the junior college by quoting from the report of the Commission which made a study of public education beyond the high school grade in California, as a result of which five fairly distinct fields in which the junior college should operate were defined:

1. The first two years of the regulation four-year curriculum in Liberal Arts and Sciences.
2. The pre-professional field for entrance into professional schools such as medicine and law.
3. A two-year course of study frankly intended as the completion of the general secondary period of education in which the facts of the physical and social world about the individual are synthesized with the purpose of aiding the student to an appreciation of the significance of these things in modern life.
4. The semi-professional field comprising one-year and two-year curricula for the preparation of young people in the middle positions, below professional grade but above vocational.
5. Promotion of the field of adult education.

These five fields of effort were indicative, Dr. Zook said, of the comprehensive nature of the junior college movement. ``It seems to me,'' he continued, ``that we have with us a great educational force which must be reckoned with.''

In conclusion, he suggested some ways of guiding the movement. First, the junior colleges should be organized into sufficiently large units as to be both effective and economical.

He urged, therefore, that all join in securing legislation that will prevent the multiplication of small and weak junior college units. The junior colleges, he believed, should be closely integrated with the secondary school system. It would be necessary for such institutions to secure more adequate financial support, better teachers, and more satisfactory facilities. He looked forward to the necessity of modification of the general scheme of engineering education to adapt itself to the future course of the junior college movement.

Contributions to the discussion of junior colleges were also made by F. C. Bolton, Texas Agricultural and Mechanical College, and by H. C. Sadler, University of Michigan.

Engineering Education in the Light of Changed Social and Economic Conditions

William E. Wickenden, Case School of Applied Science, began his address on the above topic by reminding his audience that the present conference represented the culmination of a train of activities covering a decade and having the ultimate purpose to develop, broaden and enrich engineering education. He pointed out that in America the establishment of the colonial system, the raising of it to political self-sufficiency, the completion of the expansion of the national domain, and the establishment of an industrial order of society, had each covered periods of about eighty years. Signs that we had now reached another turning point were apparent on every hand. The last two of the epochs already completed had been highly significant for the technical professions, and if a new deal were impending the engineer was likely to find his work and prospects directly affected.

Passing quickly in review over these two important epochs, Dr. Wickenden summarized the altered conditions which foreshadowed a new epoch as (1) adequate capacity to produce, with the use of barely one third of the population to supply material necessities; (2) the stabilization of population with an altered scale of resource valuations and a lowered pace of industrial expansion; (3) the reversal of our international economic position from debtor to creditor, and, in prospect, of importer; and (4) the growing ascendancy of corporate over individual interests and of functional over political interests.

He then cited a number of social adjustments to these altered bases of national economy that were now taking form. First, there was the new balance to be struck between agriculture and industry, in which the engineer and chemist might be called upon to broaden the industrial outlet for agricultural products and to by-process waste materials. Second, a new balance was being struck between consuming and producing power which would inevitably carry with it a new valuation of goods, economic security, leisure, recreation, and cultural opportunity as the rewards of human effort, and because of which the scientific worker of the future would have to look more largely to the consumer for employment. Third, the new balance between internal and international economy might result in a substitution of technical superiority for a tariff wall as a source of protection. Fourth, public enterprise and private industry would be found in a new balance, with the result that a new type of government, based on industrial and occupational interests, might grow up alongside of our present government which was based on geographical and political interests. Fifth, a new balance between realistic and idealistic forms of education was to be struck as a result of an increase in the relatively greater numbers of adults of later maturity in our population. Sixth, there would be a new balance between utility and economy on the one hand and convenience and beauty on the other. Seventh, there was hope for a changing attitude in the realm of industrial ethics toward the making of wealth, which might insist that the process of making money, as well as its disposition, should directly serve social ends.

Dr. Wickenden next asked the question: What has the engineer to gain or lose in such changes of balance, and what distinctive contribution can he make to a new age? The historic rôle of the engineer, he said, had been to take the guesswork out of construction and production by a blend of horse sense and science, and to put self-interest in the background under a code of professional ethics and responsibility. The place which he would be able to claim in a changing society would depend on his ability to change with it, to bring new scientific resources to bear, and to broaden the area to which he applied his characteristic procedures.

The engineer of tomorrow, said Dr. Wickenden, could not afford to slight the study of history, economics, sociology, and political science. This did not imply, however, that the engineer would become a propagandist or a revolutionary. He would not necessarily displace bankers, lawyers, economists, journalists, social workers, and politicians in the direction of our common concerns. His field of natural leadership was that of factual, analytical, constructive planning and of action on material problems.

In coming to a consideration of educational functions and processes, Dr. Wickenden said that engineers would continue to deal primarily with things and forces and incidentally with persons and social relations. Until a better equilibrium could be reached between technical and social control, the safety of society demanded a type of leadership in industry highly sensitized on the side of social ethics. It was the business of the engineering profession to provide leadership. In his opinion, the engineer of the present lacked a sufficiently humane understanding of the results of his work on men as persons.

The core of the educational program, he said, was the recruitment and training of an inner nucleus of prefessional engineers. The problem was now qualitative, rather than quantitative. We had no concern with the young man who lacked ability, or interest, or the preparation to *master* a group of sciences basic to engineering. Our concern as educators, he said, was to develop men who would be able to deal in a more statesmanlike manner with the major economic and social problems within their normal areas of responsibility, and it was encouraging to note that the newly formed Engineers'

Council for Professional Development contemplated a scheme of educational guidance reaching down into the secondary school, bridging the college period, covering the early years of professional activity, and envisaging some comprehensive appraisal of educational attainment at a mature level as a qualifying standard for certification into the profession.

In closing, Dr. Wickenden said: ''Society will choose its leaders from every calling, and we may confidently hope that the engineering group will supply an even more generous share than in the past, but if we turn aside from the training of men who are specially qualified to direct the great sources of power and the treasures of nature's storehouse to the service of men, with an enlightened scale of social values and under an austere code of professional integrity and duty, we do so at the peril of our civilization.''

External Relationship

H. H. Horner, Assistant Commissioner of Higher Education, The University of the State of New York, in discussing the relationship of the state and engineering education spoke specifically with reference to the State of New York, mentioning the qualifications with respect to education and training that must be met by candidates for licenses as professional engineers and land surveyors after January 1, 1937. He also called attention to the fact that the State Education Department is now engaged in revising its list of registered schools. This, as well as other steps in relation to engineering and to engineering education, is being done, in part, in coöperation with the deans of engineering schools in the State, who are called into frequent conferences. The department is also considering the matter of degrees conferred by engineering colleges and is endeavoring to unify practice in this connection.

Accrediting Engineering Colleges

H. P. Hammond, Polytechnic Institute of Brooklyn, speaking as a member of the Committee on Engineering Schools of the Engineers' Council for Professional Development dealt with the problem of accrediting engineering colleges, spoke of the steps being taken by the Council to arrive at a basis of accrediting, and outlined the fundamental principles involved in preparing such a basis. ''Emphasis,'' he said, ''will be placed upon quality of work more largely than it has in the past in accrediting procedures.'' A basis of factual data will have to be laid upon which judgment would, in part, be based. Professor Hammond spoke of accrediting of engineering schools as an actual condition to be dealt with, not an abstract matter of theory, and pointed to the fact that the newly formed Council afforded an agency for the solution of the problem in which all of the parties having a direct interest were represented.

ACTIONS TAKEN BY THE CONFERENCE

At the concluding session of the Conference resolutions and motions were introduced on a number of topics which had been discussed, formally or informally, during the course of the meetings. All were passed unanimously. The substance of the motions is given below.

(1) A resolution endorsing the concept of the Summer School for Engineering Teachers and suggesting that a committee be appointed to make recommendation for such variations in method, organization and concept as may be desirable and to report to the Council of the Society.

(2) A motion requesting the President of the Society to appoint a committee to confer with the editors of ''American Men of Science'' as to the practicability of classifying engineers in a class-group instead of under the title of physicists or chemists.

(3) A motion requesting the President of the Society to appoint a committee to marshal the facts regarding titles of degrees and to examine the desirability of uniform practices therein.

(4) A motion requesting the President of the Society to appoint a committee to consider the subject of the length of the undergraduate engineering curriculum.

(5) Resolutions embodying the appreciative thanks of the conference to the authorities of the University of Wisconsin for the excellent provisions for the comfort and entertainment of the members during the session and to the Society's Board of Investigation and Coördination for arranging the program and securing the speakers for the meetings.

APPENDIX

Program of the Conference of Administrative Officers of Engineering Colleges, Madison, Wisconsin

Monday, July 3

A.M. *Opening session called to order ....Charles F. Scott,
Chairman, Board of Investigation and Coördination,
S. P. E. E., presiding

*What is Happening to Engineering Education
A symposium led by ....H. S. Rogers,
Oregon State Agricultural College

With discussions by Blake R. Van Leer, University of Florida; H. S. Evans, University of Colorado; Williard C. Hotchkiss, Armour Institute of Technology; R. L. Sackett, Pennsylvania State College.

P.M. Session on Financial Problems ....R. A. Seaton,
Kansas State College, presiding

*The Financial Outlook for Higher Education
in the Next Decade ....Charles R. Mann,
Director, American Council on Education

General Discussion.

Tuesday, July 4

A.M. Session on Personnel Matters ....F. E. Turneaure,
University of Wisconsin, presiding

† What Can We Do to Aid the Student
Affected by the Depression? ....Edward C. Elliott,
Purdue University

Recent Engineering Graduates ....Paul Cloke,
University of Maine

Education for Unemployed Engineers ....J. W. Barker,
Columbia University

P.M. Session on Administrative Problems .....W. E. Wickenden,
President, S. P. E. E., presiding

*Faculty Aspects ....Dexter S. Kimball,
Cornell University

Budgeting and Finance ....O. M. Leland,
University of Minnesota

Wednesday, July 5

A.M. Session on Faculties ....R. L. Sackett,
Pennsylvania State College, presiding

---

* Published; Proceedings, V. 41, pp. 117–170; Jnl. Eng. Ed., Oct., 1933; also in Pamphlet listed on page 1280.

† Published; Proceedings, V. 41, p. 383; Jnl. Eng. Ed., Feb., 1934; also in Pamphlet listed on page 1280.

*Selection and Development of Faculties ....J. W. Barker,
Columbia University

General Discussion.

P.M. Session on Graduate Work ....Dexter S. Kimball,
Cornell University, presiding

*Function of the Administrative Officer
with Reference to Graduate Work ......Dugald C. Jackson,
Massachusetts Institute of Technology

General discussion led by R. A. Seaton, Kansas State College

Thursday, July 6

A.M. Session on Junior Colleges ....Paul Cloke,
University of Maine, presiding

*Junior Colleges and Their Relationship to
Engineering Education ....George F. Zook,
U. S. Commissioner of Education

Discussion by H. C. Sadler, University of Michigan, and F. C. Bolton, Agricultural and Mechanical College of Texas

P.M. Reserved for symposium on topics suggested by members of the Conference

*Public Address. Engineering Education
in the Light of Changed Economic and
Industrial Conditions ....W. E. Wickenden,
Case School of Applied Science

Friday, July 7

A.M. Session on External Relationships of
Engineering Colleges ....Dugald C. Jackson,
Massachusetts Institute of Technology, presiding

† The State and Engineering Education ....H. H. Horner,
Assistant Commissioner for Higher Education
The University of the State of New York

Discussion by C. C. Williams, State University of Iowa

*The Problem of Accrediting Engineering Colleges,
H. P. Hammond,
Polytechnic Institute of Brooklyn

---

* Published; Proceedings, V. 41, pp. 117–170; Jnl. Eng. Ed., Oct., 1933; also in Pamphlet listed on page 1280.

† Published; Proceedings, V. 41, p. 388; Jnl. Eng. Ed., Feb., 1934; also in Pamphlet listed on page 1280.

1930 SURVEY OF ENGINEERING EDUCATION *

Introductory Statement

This survey is supplementary to the earlier fact-gathering stage of the investigation of engineering education conducted by the Society through its Board of Investigation and Coördination. This later survey was undertaken to secure up-to-date data concerning engineering schools, with the thought that such surveys might be made at recurring periods in the future. The progress made by various institutions would be indicated by comparison of the new data with those obtained five years earlier and published in the reports issued in 1926, which appear in Volume I.

This survey was proposed and organized by General R. I. Rees, President of the Society and member of the Board in 1929–30. At the request of the Society, the Office of Education, Department of the Interior, Washington, D. C., coöperated in the survey. The questionnaires were accompanied by a letter from William John Cooper, United States Commissioner of Education, and were sent to approximately 150 institutions which had taken part in the general investigation.

Acknowledgment is due to Dr. Walton C. John, Specialist in Higher Education of the Office of Education, and to Mr. Ovid W. Eshbach of the American Telephone and Telegraph Company who contributed greatly to the preparation and issuance of the questionnaires and to the compilation of the report.

The report compiled from the replies to the questionnaire (which follows the report), with references to corresponding data in earlier reports, is given on the following pages.

---

* Presented at the 38th annual meeting of the Society for the Promotion of Engineering Education at Montreal, June, 1930, by F. L. Bishop, Secretary of the Society.

REPORT OF THE 1930 SURVEY

This Report is based on the Replies to Questionnaire (see page 1230) issued to Engineering Colleges in January, 1930. It is classified under the headings in the following outline.

Topical Outline of the Report

I. Administration; Enrollment and Related Factors

1. Undergraduate Enrollment, December, 1929 1165
2. Admissions, 1929 1165
3. Enrollment by Classes 1166
4. Enrollment by Courses 1166
5. Future Graduations, Estimated 1166
6. Graduate Students, Day Courses 1167
7. Evening Collegiate Courses 1167
8. Eliminations in Three Classes 1168
9. Enrollment in Three Classes 1169

II. Student Selection and Educational Guidance

1. Selection of Freshmen 1170
2. Contacts with Secondary Schools 1170
3. Guidance and Orientation of Freshmen 1171

III. Courses and Curricula

1 (*a*). Entrance Units Required 1171
1 (*b*). Hours for Graduation 1172
2. Educational Policies and Curricula 1172
3. Graduate Courses; Number and Quality 1184
4. Graduate Courses; Administration 1189

IV. Educational Development

1. Teaching Methods; Changes 1196
2. Teaching Methods; Experiments 1202
3. Teaching Load 1207
4. Salaries of Engineering Teachers 1208
5. Research and Publications 1208
6. S. P. E. E. Summer Schools 1209
    (*a*) Expenses 1209
    (*b*) Value 1209

V. Graduate Placement and Demand

1 (*a*). Methods in Placement of Seniors 1212
1 (*b*). Placement Records 1212
2. Employment Information 1221
3. Opportunities in 1929 1228
4. Initial Salaries of Graduates, 1929 1228

PART I

ADMINISTRATION; ENROLLMENTS AND RELATED FACTORS

1. TOTAL UNDERGRADUATE ENGINEERING ENROLLMENT DECEMBER 31, 1929

(For comparative enrollment see Journal of Engineering Education, June, 1928, and Proceedings, Vol. XXXV, Page 951)

Distribution by Classes in 119 Institutions	58,853 Students
Probable Enrollment in 145 Institutions	70,000

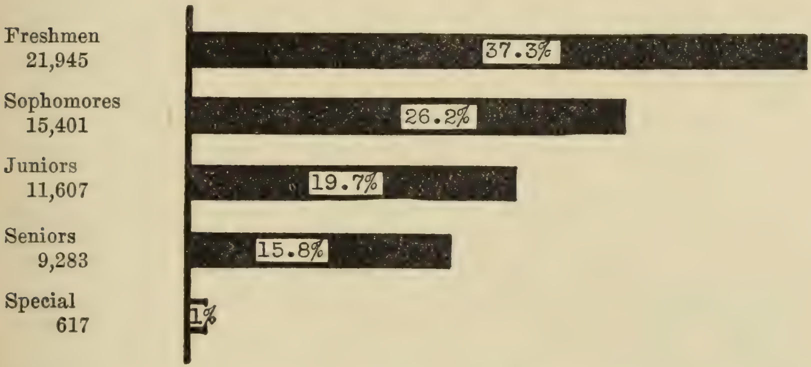


FIG. 1. Distribution by Classes; 58,853 Students

2. ADMISSIONS;* DATA FROM 83 INSTITUTIONS

(*a*) Number of Freshmen admitted in 1929	17,840
(*b*) Number of Freshmen admitted with conditions	3,041
(*c*) Students admitted to advanced standing	2,618
1. From other Engineering Schools	601
2. From other collegiate schools	1,714
3. Transfers from other courses	303

* Pages 218 and 221.

3. Percentage Distribution of Class Enrollments by Engineering Courses December 31, 1929

	Class			
	Senior	Junior	Sophomore	Freshmen
Electrical Engineering	29.8	29.0	26.2	27.9
Mechanical Engineering	19.1	20.5	22.6	22.7
Civil Engineering	25.1	23.9	20.6	19.5
Chemical Engineering and Chemistry	11.0	11.2	13.2	13.1
Mining Engineering	1.3	1.4	1.9	1.7
Industrial, Administrative and Commercial Engineering	4.0	3.6	2.9	1.4
Architectural Engineering	3.4	4.0	4.1	4.4
Aeronautical Engineering	2.0	1.7	3.3	2.9
Metallurgy	.8	1.8	.8	.7
Other	3.5	2.9	4.4	5.7
Total	100.0	100.0	100.0	100.0
Number of Students	6,267	7,852	10,007	10,418
Number of Institutions	75	74	65	43

4. Percentage Distribution of Enrollment in Six Major Courses

	First Degrees Conferred				Enrollments Dec. 31, 1929			
	1922	1924	1926	1928	Senior	Junior	Sophomore	Freshmen
Electrical Engineering	23.5	28.2	31.2	35.5	33.3	32.2	29.6	31.3
Mechanical Engineering	26.4	28.3	25.2	22.5	21.2	22.6	25.4	25.4
Civil Engineering	25.4	24.0	26.0	26.0	28.0	26.7	23.3	21.9
Chemical Engineering and Chemistry	15.9	11.5	10.3	9.7	12.3	12.5	15.0	14.7
Mining Engineering	7.3	6.9	5.7	3.9	1.4	1.5	2.1	1.8
Architectural Eng'r.	1.5	1.1	1.6	2.4	3.8	4.5	4.6	4.9
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

5. Probable Number of Future Graduations *

Calculation Based on Growth In Fifty-eight Colleges of Engineering

Year of Graduation	First Degrees Per cent of 1928	
	Minimum	Probable
1927	96.4	96.4
1928	100.0	100.0
1929	107.4	107.4
1930	106.3	109.4
1931	114.5	118.8
1932	114.8	123.1
1933	115.6	124.4

Number of degrees in 1928—8,278

---

* Page 221.

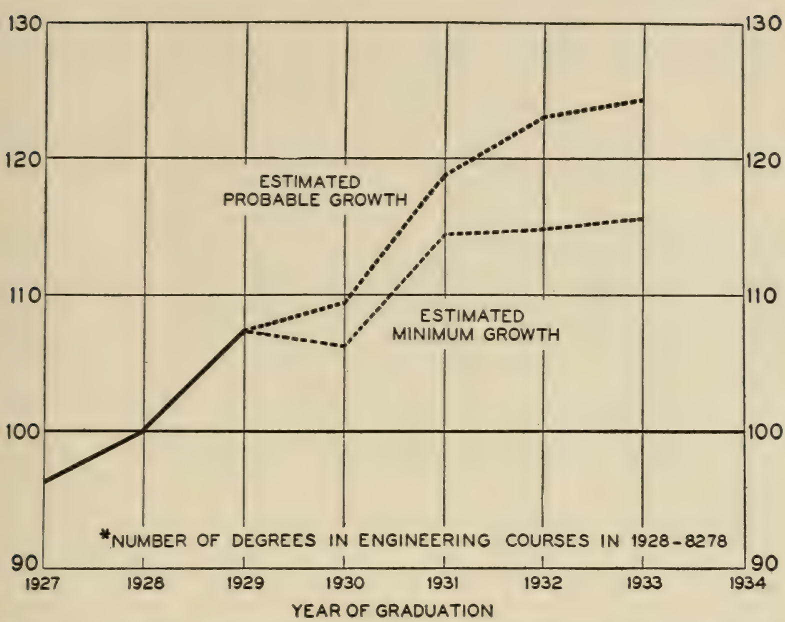


FIG. 2. Estimated Percentage Increase in Graduates 1930–33. See Table 5

6. ENROLLMENT OF GRADUATE STUDENTS IN DAY COURSES DECEMBER 31, 1929 *

	Degree			Total
	Engrg.	M. S.	Ph. D.	
Engineering	710	837	61	1,608
Physics	6	153	155	314
Chemistry	9	345	311	665
TOTAL	725	1,335	527	2,587

Data from 110 institutions. 71 institutions reported a total enrollment of 2,835 students, 248 of whom were unclassified. 39 institutions reported no graduate courses.

7. ENROLLMENT IN EVENING COURSES IN COLLEGIATE ENGINEERING SUBJECTS DECEMBER 31, 1929 †

Institutions included	111
Number offering Evening Courses	22
Number receiving credit for Bachelor Degree	4,463
Number receiving credit for Graduate Degree	1,760
Number of students not candidates for degree	7,933
Unclassified	1,850
Total Enrollment in Evening Courses	16,006

* Page 322.

† Page 324.

8. Record of Total Eliminations in Three Classes *

	Class Graduating in						Average Percentage	1926 Report
	1927		1928		1929			
	No.	Per Cent	No.	Per Cent	No.	Per Cent		
Number of Freshmen Admitted	7,696	100.0	8,915	100.0	9,519	100.0	100.0	100.0
Number Remaining After One Year	4,615	60.0	5,623	63.1	6,992	73.4	65.5	60.6
Number Remaining After Two Years	3,418	44.5	4,241	47.6	4,441	46.7	46.3	42.1
Number Remaining After Three Years	2,821	36.7	3,548	39.8	3,810	40.0	38.8	33.8
Number Graduating in Four Years	2,159	28.1	2,392	26.9	2,613	27.5	27.5	28.1
Number Graduating in Five Years	470	6.1	559	6.3	311		6.2	
Number Still in College	82	1.1	191	2.1	763		1.6	
Number of Institutions	47		49		52			25

Record of Eliminations

Of 90 institutions, 42 reported that the college records indicated the cause of eliminations, 20 said the records only partly gave the causes, and 28 reported they did not.

Causes of Elimination †

Of 112 institutions, 69 gave no report, 21 stated what they believed the principal causes to be, and 22 others gave some detailed analysis of the causes. An analysis of the reasons given by the 21 institutions is as follows:

Reason	Given by
Scholastic Difficulty or poor ability	15
Finances	13
Lack of Preparation	8
Lack of Aptitude and Interest	6
Outside Work	4
Mathematics	3
Ill Health	3

A review of the detailed analysis as given by 22 institutions indicates the principal reasons in order of importance to be as follows: Scholarship, Health, Finances, Personal, Lack of Interest, Preparation, Transfers to other colleges and departments.

---

* Page 200.

† Page 210.

9. Enrollment Record of Three Classes, Including Eliminations and Additions in Successive Years

	Class Graduating in						Average Percentage
	1927		1928		1929		
	No.	Per Cent	No.	Per Cent	No.	Per Cent	
Freshmen	10,233	100.0	11,652	100.0	11,886	100.0	100.0
Sophomores	7,415	72.5	8,350	71.8	8,691	73.1	72.5
Juniors	5,484	53.6	6,092	52.3	6,307	53.0	53.0
Seniors	4,661	45.5	5,233	44.9	5,384	45.3	45.2
Graduating	4,104	40.1	4,533	38.9	4,732	39.8	39.6
No. of Institutions	56		59		60		

Note.—Enrollments taken at the beginning of each school year.

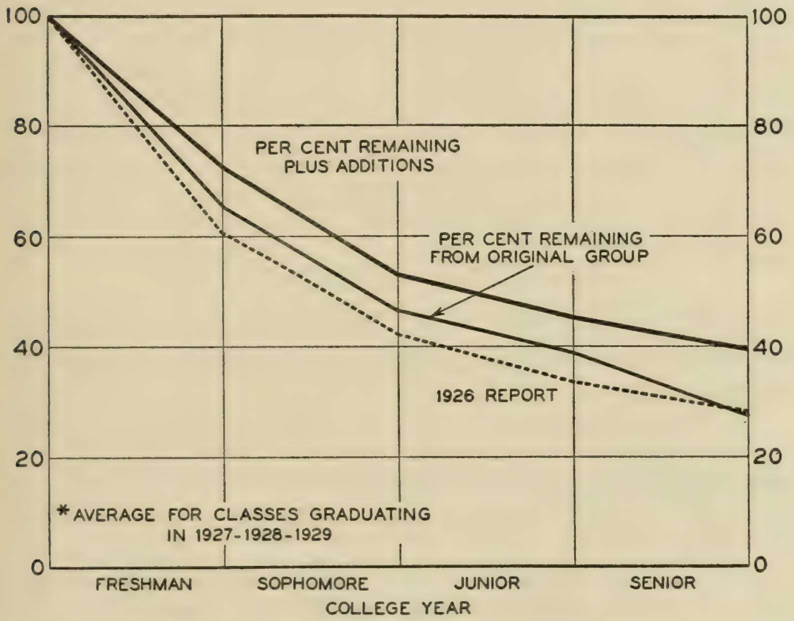


Fig. 3. Enrollments from Entrance to Graduation. Upper Curve: Enrollment (classes 1927, '28, '29) at beginning of each year and at graduation. Item 9. Middle Curve: Enrollment of original group. Item 8. Lower Curve: Enrollment of original group; 1926 Report, see page 202.

10. Tuition for Engineering Courses

Data from 87 Institutions

Tuition Per Year	Number of Institutions
$400 to $450	11
300 to 399	13
200 to 299	16
100 to 199	17
Under $100	30
Total	87

PART II

STUDENT SELECTION AND EDUCATIONAL GUIDANCE

1. Selection of Freshmen *

Of the 103 institutions, 84 reported admission on the basis of certificate from high school or college board examination. Five required either examination at the institution or college board examination, 13 limited admission to those in a specified portion of their high school class, 11 required a personal interview, 13 used psychological or aptitude tests in addition to the certificate, 13 mentioned other considerations, such as character testimonials and achievements in extra-curricula affairs, 2 required a medical examination and 5 reported no method of selection.

2. Contacts with Secondary Schools †

Of 103 institutions, 58 reported some systematic contact with secondary schools, 34 made no effort in this direction and 11 gave no report.

Forty-nine institutions reported that the contacts had resulted either in improved matriculants, better understanding, better cooperation, and improved preparation, and thought it very worth while. Two were doubtful of the benefits and 3 reported no improvements.

It is apparent that many of the institutions have only recently established these contacts but the reports from them indicate considerable confidence in the desirability of continued contact.

---

* Page 196.

† Page 172.

3. Educational Guidance and Orientation of Freshmen *

Data from 103 Institutions

Method Used	Number of Institutions Yes	No
Freshmen Week	73	23
Engineering Problems Course	29	67
Required Orientation Lectures	52	44
Series of Unrequired Talks or Lectures	22	74
Faculty Advisors	68	28

Institutions using none	7
Institutions using 1 method	13
Institutions using 2 methods	30
Institutions using 3 methods	37
Institutions using 4 methods	14
Institutions using 5 methods	2
TOTAL	103

Seventy-three institutions reported the following amounts of time for "Freshmen Week."

1 Day	5	Institutions
2 Days	6	"
3 Days	27	"
4 Days	12	"
5 Days	16	"
1 Week	6	"
9 Days	1	"

---

* Page 183.

PART III

COURSES AND CURRICULA

1 (*a*). Entrance Units Required in Particular Subjects *

Data from Eighty-six Schools

Subjects	Number of Institutions					
	0 Unit	½ Unit	1 Unit	1½ Units	2 Units	2½ Units
Algebra	2	0	9	52	22	1
Solid Geometry	15	60	5	3	1	0
Trigonometry	65	18	0	1	0	0
Solid Geometry or Trigonometry	—	2	—	—	—	—
Physics	36	3	30	0	0	0
Chemistry	52	0	17	0	0	0
Physics or Chemistry	—	—	17	—	—	—

---

* Page 429.

† Pages 430–439.

1 (*b*). SEMESTER HOURS REQUIRED FOR GRADUATION †

Average Figures for Six Major Courses

Subjects	E. E.	M. E.	C. E.	CH. E.	E. M.	I. E.
Mathematics	18.5	18.1	18.2	17.9	16.5	15.6
Physical Science	20.7	19.3	20.0	25.2	22.2	21.5
English	9.0	8.9	9.1	8.7	7.5	11.2
Modern Foreign Languages	1.2	1.0	1.2	5.3	1.8	1.9
Economics	4.7	5.0	5.3	4.3	4.5	11.9
Technological Subjects, Major Branch	39.0	41.0	50.0	44.9	45.4	34.2
Other Technical Subjects	23.5	22.9	18.4	21.6	31.2	22.4
Shop	4.6	7.2	1.7	1.9	1.2	6.4
Drawing	7.2	7.8	7.1	5.6	6.4	8.2
Electives	10.4	9.3	8.4	6.7	5.9	12.2
Physical & Military Education	4.6	5.0	4.6	4.3	5.1	4.9
Total	143.4	145.5	144.0	146.4	147.7	150.4
Number of Institutions	51	44	51	41	15	17

2. EDUCATIONAL POLICY AND CURRICULA; REPLIES TO QUESTION

What significant changes in educational policy or curricula have taken place in the last five years?

No. 1. When the results of the Survey of Engineering Education were published, the entire educational policy and curriculum were carefully reviewed. Our existing practices were found to be in practically complete accordance with those followed in other engineering schools of repute. A few minor changes were made, to bring about rather better distribution of students' time. No significant changes were found necessary.

No. 2. Change of degree practice—5 year chemical engineering course reduced to 4 year—Requirements for entrance raised—Revised curriculum evening graduate work instituted.

No. 4. Little change, except amount of mathematics required is being reduced. There is a tendency toward lightening schedules, especially in the sophomore year.

No. 5. In April, 1924, our curricula was revised so as to reduce the normal load of the student from 23 semester hours to 20. In December, 1927, a further revision was made in order to reduce most of our courses to a three-hour basis, in this way simplifying the schedule. The total load on the student was not changed but considerable readjustment was necessary.

No. 7. Complete reorganization of Chemical Engineering Department and chemical engineering curriculum. The introduction of a course on the calculus of probabilities for all seniors. The introduction of "Honors Courses."

No. 8. Five-year course instituted five years ago; coöperative in last four years in three-month alternative periods.

No. 10. There have been no radical changes. From the usual departmental staff conferences minor changes have been made from time to time in subject matter, in methods of presentation, and in proportion of time assigned to preparation, to lecture, to classroom work, and to laboratory work.

There has been development and some extension of coöperative education. The coöperative courses in chemical engineering, it is believed, have been steadily improved, and are of demonstrated worth. A coöperative course has been added recently in railroad engineering. There has been development and extension of the summer camp courses in civil and in mining engineering.

No. 13. Standards are being raised steadily on the lines of the S. P. E. E. recommendations.

No. 15. No change found to be advisable. Courses are kept in step with developments.

No. 16. No marked changes have been made. Minor changes in conduct of certain courses. Four years ago mechanics (statics) was taken out of the second semester of the freshman year and moved forward into the sophomore year. A course, introduction to engineering, was substituted in freshman year and other necessary changes made.

No. 17. All of the engineering curricula have been revised to approach the recommendations of the S. P. E. E. Committee on Investigation and Coördination.

No. 18. Beginning 1930–31 the engineering courses will be administered under a School of Engineering, whereas heretofore they have been conducted in the School of Sciences, which included the degrees B.S. (general) and B.S. (pre-medical). With a view to the inauguration of the new plan, the 1929–30 freshmen were enrolled as students in the School of Engineering.

No. 19. Up to four years ago three years of collegiate pre-engineering work was required as a minimum for admission to the Engineering School. Four years ago a two-year collegiate requirement as a minimum was put into effect.

No. 25. The following changes have been made. The elimination of the Department of Arts and Sciences within which the engineering work was formerly conducted, making the School of Engineering a primary, instead of a secondary, division of the university organization.

Transfer of the Department of Architecture to the newly created Division of Fine Arts. The elimination of graduate courses in engineering. The elimination of the degrees of B.S. in chemical engineering, B.S. in chemistry, and B.S. in physics (some students who registered prior to 1928 are completing work for these degrees).

The establishment of a course leading to the degree of B.S. in engineering which will go into effect in 1930–31.

No. 27. Introduced the grade point system as one basis for rating and encouraging the production of scholarship. Increase in number of non-engineering courses. Equalized the number of hours work required in each branch of engineering. Course in building construction added as an option in civil engineering.

No. 31. In 1925 we had a five-year coöperative course with four week periods of which the first year was non-coöperative. In 1925 we reëstablished summer surveying camp.

In 1926 we made first two years non-coöperative. We made courses in physics and calculus stronger. We unified the first three years of instruction, making them identical in all curricula. We added a course in theory of structures to all curricula. We increased the hours in corporation finance. We transferred economics to the sophomore year. We added physical chemistry, electro-chemistry, and thermo-chemistry to Ch.E. course. We strengthened C.E. courses in highways, and concrete. We increased M.E. course in machine design. We added concrete to M.E. and E.E. curricula.

In 1927 we standardized on 48 hours' combined recitation and preparation as one semester hour and rated all our credits to nearest ¼ semester hours. (We have 18-, 20-, 11-, and 7-week semesters.)

In 1929 we added a course in aeronautical engineering.

No. 32. Curriculum hours reduced. Common freshman year for all divisions. Highly technical subjects made elective.

Addition of industrial options in M.E. and A.E. Coöperative system open to all divisions.

No. 33. Beginning in September, 1929, all curricula in engineering were reorganized on a five-year program (one year full time and four years coöperative) and the old four-year curricula were abolished. This makes possible the inclusion of more cultural subjects and the better distribution of technical subjects throughout the curricula.

No. 34. Foreign language has been dropped as a requirement for graduation. Allowing a greater degree of freedom in selecting additional economics and courses in business in our School of Commerce. Giving at the end of four years the degree of B.S. (in Eng.) whereas formerly the College of Liberal Arts granted the B.S. degree to our fourth year men. Allowing fifth year students for the degrees of C.E., E.E., M.E. and I.E. a greater degree of freedom as to electives.

No. 36. We have changed from a school requiring three years for graduation, summer quarter being included, to a school demanding four years for graduation, no summer quarter being required unless it is for failure in previous work. The three-year course requires no English or economics, while a four-year course demands that a student study nine hours of English and nine hours of economics for three quarters.

No. 38. Lessening the required courses of freshman year from 20 credit hours to 16½ credit hours. Doing away with foreign language requirements. Introduction of electives. Revision of coöperative work. Introduction of required business courses.

No. 39. The rearrangement of courses to equalize the different years. Drawing has been reduced to give surveying to all men. Certain laboratory courses have been added.

No. 42. The College of Engineering began to function in the fall of 1928 with five divisions of engineering—chemical, civil, electrical, mechanical, and petroleum. Mechanical engineering was comparatively new at that time, and petroleum engineering was really a course in petroleum geology fostered by the Department of Geology. The Division of Chemical Engineering has thus far been identified with the Department of Chemistry and will probably continue to develop that way. The professors of chemistry are on the staff of the College of Engineering as well as of the College of Letters, Arts, and Sciences.

In electrical engineering we have just employed a man to give special attention to radio and high frequency work and to develop experimental work in general for us. In mechanical engineering there has been a very definite demand for work in aeronautics, and we have added six courses in aeronautical engineering to our curriculum in that division. A year ago the course in petroleum engineering was completely revised and an outstanding man was appointed to conduct this work. Inasmuch as the university is located in the midst of the greatest oil field activity in the State, it seems especially appropriate to develop this work.

During a number of years we have discussed in our faculty meetings the matter of giving work which would fit men particularly for commercial and industrial work, and hence we shall have, beginning next fall, a course called General Engineering which will include the fundamentals of engineering training and enough work in economics and commerce to make our students useful in a commercial and industrial way. In the Division of General Engineering we have included such work as general engineering, drawing, mechanics, materials, and engineering economics.

No. 44. The introduction of a certain limited number of free electives and a reduction in the amount of time devoted to shop and design courses.

No. 46. Reduction in number of hours devoted to ''shopwork'' and increase in number devoted to mechanical drawing and mathematics.

No. 48. More attention given to aero-dynamics and aero-plane design.

No. 49. Beginning in September, 1930, no applicants will be admitted who do not present 1½ units in algebra and 1½ units in plane and solid geometry. Applicants for admission whose rank was in lowest third of high school class must pass entrance examinations in algebra, plane and solid geometry, English, a general intelligence test, and in 4 additional units selected from high school list of credits. Curriculum requirement in English raised from 8 to 10 units. Average grade required for graduation has been materially raised.

No. 51. Men with honor stand (B or better) allowed considerable latitude for independent work. Curricula have not changed materially during five-year period.

No. 52. (Explanation of credit hour.) A credit hour normally consists of one hour of classroom work or equivalent pursued each week for a semester of ten weeks. Two laboratory hours are considered equivalent to one classroom hour.

No. 57. No significant changes in educational policy. We are reviewing our curricula carefully at present and there may be changes within the year.

No. 61. Fixing on 17-hour semester. Eliminating foreign language requirement. Cutting down on drawing and shop time. Reducing required engineering hours and making more elective hours. Creating a basic, or ''general engineering'' course, required of all engineering (except Ch.E.) students, so that a student may take his B.S. in general engineering, and have his 26 elective hours free. If his major is E.E., M.E., or C.E., the faculty of engineering may require that 12 of his elective hours be spent in advanced work in his chosen field.

No. 62. None. Our curriculum has been developed during the past five years, and all courses in the senior year were offered for the first time this year.

No. 63. None, but now under consideration.

No. 67. An adjustment has been made in the curricula making room for electives as indicated above. A required course in economics has been arranged in the sophomore year with the thought in mind that it will serve as a prerequisite to elective courses in economics or business administration in the junior and senior years.

No. 68. Until 1927, all courses (except Ch.E.) were alike until the senior year. Now the differentiation begins with the sophomore year. This differentiation in the senior year will be increased somewhat next year.

No. 69. Trend to more work in economics.

No. 70. A combined 6-year engineering-law course, 3 in engineering and 3 in law. The fourth year taken in the Law School. Grades in engineering necessary for recommendation between B and C. A course in ''transportation'' combining work in civil, mechanical, electrical, marine, aero, economics, etc.

Each sub-department is considering a possible complete rearrangement of its undergraduate work, bearing in mind that there are in general three types of men to educate: (*a*) those who expect to go into industry generally, (*b*) those who expect to become ''professional'' engineers, (*c*) those who expect to go into research work. Probably the last two will need an extra year.

No. 71. Addition of chemical engineering and general engineering courses.

No. 72. The discontinuance of a general engineering course.

No. 74. All curricula have been made identical through the first two years. (Effective 1927–28).

No. 75. A student may, by the permission of his adviser and with the approval of the Dean, be relieved from a professional requirement and substitute a special problem.

No. 79. Tendency to include more business and economics in engineering curricula and to make the engineering courses more the teaching of fundamentals rather than of practical details. Gradually courses in economics (general) and engineering economics are being introduced. To make room for these courses some of the details of the engineering courses are curtailed and the courses shortened or even omitted.

No. 82. Practically none.

No. 84. In E.E., M.E., Mar.E., the elimination of required courses in pattern making (4 units) and machine shop (4 units). There are now required 4 units of ''materials treatment'' including heat treatment, welding, cutting, shop demonstrations in wood and iron, etc. The requirement by State legislature of 2 units of American institutions was added two or three years ago.

No. 85. No marked changes.

No. 87. Qualifying test for entrance. Change in maximum and minimum hours that students in Engineering College may take. A student must take at least 14 credit hours and in general will not be allowed to take more than 19. If, however, during the preceding semester he obtains an honor point average of 2.5 he may be permitted to take as many as 20. If the average was 3, 21.

Concerning the honor point system, in the Engineering College the student must fulfill the requirements of the curriculum with a standing of 1 in order to graduate. Very few important changes have been made in curricula in the last 5 years. Some subjects given in the junior year have been changed to the sophomore year and a few minor subjects have been added. Changes will be made in the year 1930–31.

No. 89. Have placed in most curricula some electives to be devoted to English, economics, etc., as the student may desire. Total number of credits required for graduation reduced from 150–152 to 145–147.

No. 91. None.

No. 93. Removed history from freshman year and replaced it by physics. We now have in this year chemistry, engineering drafting, English, mathematics, military, physics, physical training—unification—progressive development.

No. 94. The senior year's work in public speaking has crystallized into the presentation, before the entire student body by the senior class, of two seminars at the close of each semester. These seminars, as they are called, consist in reproducing, as nearly as may be, a hearing or similar situation, the principal parts being taken by the seniors and some juniors. The freshmen make brief reports of these seminars. The entire term is spent by the seniors in preparing and collecting their material and developing their arguments.

No. 96. The most significant change that has taken place in our educational policy has been the increasing of the number of credit hours in the various curricula. For a number of years we have been operating on the basis of a normal of 15 units or credits per semester. We have changed this policy and now our standard is 17 per semester or 136 credits for the Bachelor's degree. Curricula common for two years with minor variations in third year for civils, electricals and mechanicals.

Attention is called to the fact that in all divisions of the university, except Engineering, the normal required credit per semester is 15 hours. The increase to 17 hours per semester in the College of Engineering throws it out of step with other divisions of the university, but in comparison with the commonly accepted standards of engineering colleges throughout the country it is still below the average. Owing to these local conditions it is likely that the present requirement of 17 hours per semester is a maximum.

No. 97. Freshman Engineering Day has been in operation three years, with sufficient success to warrant the establishment of an all-university Freshman Day, just prior to registration. Freshman adviser is given more time for contact. Freshman orientation continues as a 1 hour course throughout the year. After 10 years of evolution, this appears as a fixture, in the form of general lectures, demonstrations, exercises, experiments. It is not a problem course.

No. 98. Less insistence on particular courses and more general cultural and scientific courses.

No. 101. Reduction in semester hours required for graduation and reduction in the number of subjects the student is pursuing at one time; greater attention to the individual student.

No. 102. Up to 1927 differential calculus was taught in the spring term of the freshman year. Beginning with the fall of 1927, calculus was made a sophomore subject, a freshman orientation course was introduced, general economics was added to the sophomore year and some other minor changes made in the curricula. The total number of semester hours required for the engineering degrees was reduced from about 152 to 144.

We are now engaged in a general revision of all the curricula with a view to bringing them still more nearly in line with the fundamental principles laid down by the Board of Investigation and Coördination of the S. P. E. E.

No. 104. No changes in theoretical essentials. Modern language dropped to satisfy necessity for more time in technical fields.

No. 105. Marked development in chemical engineering. Facilities in ceramics have been greatly increased. Full option and new laboratory for sanitary engineering. Changes in mechanical engineering to provide additional optional work in mechanical engineering power and electrical engineering. Greater emphasis on economic content of courses. Minor changes in all curricula.

No. 106. Free electives have generally been increased.

No. 107. Findings of the S. P. E. E. used as a guide in changes still in progress.

No. 111. A general scrutiny of all subject matter and elimination of obsolete material. Emphasis of motivation courses in the freshman year. Increase in amount of economics and history.

No. 112. Elimination of thesis requirement in all curricula. Introduction of electives in nearly all curricula. Reduction in number of credit hours required for graduation (average requirement for graduation is two credit hours less than it was five years ago).

No. 113. Installation of specialized courses in highway, sanitary and metallurgical engineering.

No. 114. All mathematics given in first two years. Applied mechanics given by technical department. Time given to economics increased and placed in sophomore year. Elementary geology dropped. Public discourse added. Descriptive geometry added.

No. 115. Extension of elective system. Curricula have been revised in harmony with the recommendations of the Society for the Promotion of Engineering Education.

No. 117. Have reduced technical and increased general subjects.

No. 118. Reduction in credit hours required for graduation from 225 to 204. This was done four years ago.

No. 120. Engineering curricula have been reorganized for the purpose of strengthening the sequences in the engineering science and technology group and for the purpose of introducing a group on economics and administration apart from the engineering angle in the senior year. The freshman instruction has been organized for the purpose of orientation and courses have been grouped in a common curriculum for the departments of mechanical, electrical, and civil engineering. A staff committee has been working upon the development and correlation of the work in the common freshman year. Another committee has made a study for the purpose of improving all matters pertaining to classroom instruction. Personnel work with educational and vocational counsel is being rapidly developed.

No. 121. The standards for entrance have been raised very definitely by accepting only those students who stand in the first or second fifth of their high school class, and requiring them to pass examinations if they stood lower than the second fifth of their high school class. The registrar states that about half of those taking entrance examinations have failed.

No. 124. The elimination of freshman shop work and the substitution of a course in "engineering problems."

No. 126. Entrance requirements raised from 15 to 16 units. Mathematics requirements raised from 3 to 3½ units. Age of special students raised from 20 to 23 years. Work in physics and economics increased. Curriculum in commercial engineering changed to industrial engineering. Options introduced in senior year of nearly all curricula. Architectural engineering added. Ceramic option offered in mining engineering.

No. 129. Degrees other than the mining and metallurgical first offered within above period.

No. 130. The curricula in metallurgical and geological engineering have been differentiated from an all inclusive course in mining engineering. We have in progress a thorough restudy by faculty of all curricula and will probably reduce somewhat the requirements for graduation, i.e., the number of hours.

No. 132. None.

No. 133. None, other than a gradual stepping up of the engineering and scientific content of the curriculum with a corresponding reduction of the requirements as to cultural courses.

No. 134. During the past five years there have been added to the engineering curriculum courses in mechanical, electrical, ceramic and chemical engineering by the cooperative plan.

No. 135. Normal changes.

No. 136. None.

No. 137. An increase in time given to English, economics and business, the laboratory, and testing equipment has been greatly increased and better instruction provided. The courses of instructions are being studied by a special committee of the faculty with expert advice from the outside. This study by special committees and final action by the faculty will probably result in changes.

No. 138. Changing from a two-week alternating period to a three-week alternating period—then to a nine-week alternating period.

No. 139. There have been no radical changes in policy or curricula during the last five years. Minor changes in technical courses are made from time to time as changing practice requires. Slight changes in the electives have been made. At the present time history is the predominant elective. The course in aeronautic engineering was offered for the first time in September, 1929. Since it utilizes the same foundation courses as the other departments and also includes some technical courses given in other departments, there will be a senior class of aeronautic engineers ready for graduation in June, 1931.

No. 140. Introduction of special sections in economics and accounting primarily planned for engineers, more freedom for election in course given in junior and senior years.

No. 142. The elimination of the subcollegiate course 1924 (Sept.). Increase of 20 hours (credit) for B.S. degree in curriculum. Increase from 50 to 55 m. period of recitations. College algebra and plane trigonometry with college credit are required (4), elementary economics (3), English (6) and other technical subjects to make up 20 hours.

No. 143. The introduction of a course in physical computations which was suggested by a close study of the engineering colleges of England and Scotland. It was felt strongly that our boys did not have sufficient sustained computations. Also, I have mentioned the course in English. Following the educational philosophy of John Dewey, we are of the opinion that it is very wise to have our college course here a cross-section of engineering life itself. Our course in English consists of a course in lectures in industrial history in the development of engineering; a list of readings for engineers which contain some classical engineering work. This furnishes the background. The young man is asked to write, write, write, write, write—a good deal of the writing being done under supervision following the principle that the only way to learn how to write is to write.

Each week, the entire freshman class is assembled with considerable formality and half a dozen papers are delivered and discussed formally by the convocation, adopting the same method as you would find in an engineering society. The results have to me been astounding, and we are gradually adding to the time spent so that ultimately we may hope to reach a 44 hour week. Much of the work done at home is done now within the college walls.

Again we are striking at the cross-section of real engineering life and I see no reason why, if we are willing to run a 44 hour week, that we should not get much of the work done within the daylight hours. From the standpoint of physiology, psychology and sociology, this would be a tremendous benefit and will solve many of the problems which have to do with lack of time and failure to apply.

No. 145. None; however, definite changes are planned and will be begun next year. (Note: We have formulated the curricula for degrees based on two years' straight college work, followed by three years on the coöperative basis. This will be put into effect beginning with our present freshman class, and will require 153 hours for graduation.)

3. Graduate Courses; Character; Replies to Question

What significant changes have taken place in the last five years regarding the number and quality of graduate courses? *

No. 1. No graduate courses.

No. 2. Five years ago a curriculum leading to M.S. degree in chemistry was the only graduate activity. Last year curricula were added leading to the Master's degree in civil, electrical and mechanical engineering and this fall another in chemical engineering. Three years ago seven courses were given and now twenty-one courses are given, both excluding supervision of thesis work. All of these courses are given during the evening hours and a few in the daytime.

No. 4. The number of graduate courses given at night is increasing steadily. Some graduate work is being done now in day courses, notably in metallurgy.

No. 5. The number of graduate students in any of the last five years has been quite small so that very little graduate work has been done on other than a personal basis.

No. 7. No graduate courses.

No. 10. A complete revision of all courses given, into three classes: (1) Undergraduate—not counting towards higher degree; (2) Graduate and Undergraduate—courses of fourth year or senior grade; (3) Graduate—open only to graduate students (except with special consent of registration officers). For the Master's Degree 75 per cent of the work *must* be elected from group (3) as a minimum, 25 per cent *may* be chosen from group (2). The number of strictly graduate courses has been and is being extended annually. In 1929–30 a total of 321 graduate courses were listed in both terms by all departments at the Institute (as many courses in the second term are continuations of courses in the first term the number of subjects offered as graduate courses is considerably less than the figure given above).

No. 11. None—more given.

No. 15. None, save greater emphasis placed on chemical engineering.

---

* Page 333.

No. 16. None.

No. 18. None.

No. 27. At present do not offer graduate courses in engineering.

No. 31. None.

No. 32. There are no graduate courses in engineering except those offered in Aeronautical School, where a fifth year in residence is required of those seeking the Aero.E. degree.

No. 33. No graduate courses are offered by the School of Engineering.

No. 34. The annual increase in graduates has been approximately 20 per cent. Approximately 55 per cent of our fourth-year graduates return to complete the fifth year for the degrees of E.E., C.E., M.E., and I.E. In the fifth year and fourth year more courses in economics and commerce are allowed.

No. 36. Graduate courses are not given at the University.

No. 38. Through a coöperative agreement with the Westinghouse Electrical and Manufacturing Company we conduct with them a coöperative graduate school in engineering, with an enrollment of about 250 graduate engineers and a varied curriculum. Many of the mature engineers of the company are on our staff as lecturers.

No. 39. Our graduate courses have been offered for the last five years only. The number is the same as that first offered. Our enrollment is increasing.

No. 44. None.

No. 46. None. We have had no resident graduate students in engineering for a number of years. Each year we have one or more graduates who are awarded the professional degree of mechanical engineer, civil engineer, electrical engineer, chemical engineer on the basis of their professional experience and an examination and thesis.

No. 49. None. Plans now being matured to develop graduate courses of instruction in all departments.

No. 51. There has been a distinct increase in the requirements in the direction of greater rigor.

No. 57. We do not offer graduate courses.

No. 62. One graduate course was offered this year. This is the first attempt to give graduate work in the School of Engineering.

No. 63. No graduate courses.

No. 67. The number of graduate courses has been increased, and much of the work has been increased in difficulty.

No. 68. They have been extended and more closely defined.

No. 70. Several new courses added in higher work in mechanics (also given in Summer School). Additional graduate courses in electrical, chemical.

No. 71. None.

No. 74. No considerable changes.

No. 79. Relatively few graduate courses are given. There is a tendency to emphasize mathematics in the graduate work in engineering.

No. 82. Began to offer a unique course (graduate) in the administration of mineral industries.

No. 83. Not giving graduate work in engineering at present.

No. 84. Little change except for an increase in the number of courses and a strong tendency to encourage graduate study.

No. 87. Until the year 1927–28 practically no graduate work was done in the College of Engineering. In that year through the provision of three graduate fellowships, one each in civil engineering, physics, and chemical engineering, an interest was started in graduate work. Regular graduate courses were offered during 1927–28 and 1928–29. Graduate students other than those awarded the graduate fellowships have been taking the advanced work leading to the degree Master of Science.

No. 89. The number of such courses has been increased considerably. The requirements now demand a higher quality of work.

No. 91. Several graduate courses in mining and metallurgy have been added.

No. 93. More courses of high quality have been added.

No. 96. No changes have been made of any importance, except that these courses are being more and more elected.

No. 97. They have all been surveyed by the Graduate Council, both as to content and instruction. Prerequisites have been more clearly defined, and distinctions drawn between graduate courses and advanced undergraduate courses.

No. 98. All that we have, have been added in the past five years. We have a few strictly graduate courses.

No. 99. In order to fulfill the objectives of the Graduate School, that is to "meet the needs of superior students who are preparing to become teachers in colleges or universities, or investigators, and to offer opportunities to qualified students for a more advanced training than they can obtain in an undergraduate course," the last five years was marked by a restriction rather than an expansion of graduate work. The number of departments represented in the graduate bulletin as offering graduate courses for major work towards the Master's degree has been reduced from 22 to 14. The number of courses in these departments has not been increased very much. The quality has been improved, particularly in the science departments. Considerable emphasis has been placed upon the requirement of a valuable thesis. In most cases the theses have been accepted for publication in reputable periodicals.

No. 101. Increased in quality and variety.

No. 102. None.

No. 104. Graduate Department of University incorporates graduate work in engineering.

No. 105. Additional courses in chemical and sanitary engineering.

No. 106. Considerable enlargement in facilities and number of courses.

No. 107. Number of courses offered has been reduced.

No. 111. Engineering graduate work here is finding itself and the subject matter of graduate courses is being placed on a truly graduate basis with emphasis on the truly research type of work. Introduction of courses and facilities for work leading to the doctorate.

No. 112. Number of courses listed in catalog about the same. Courses are better organized and more are being actually given.

No. 115. None.

No. 117. Number about same. Quality much improved.

No. 119. Graduate work was not offered five years ago. At the present time complete graduate and Masters' degrees are offered in the Departments of Industrial Arts, Education, and Vocational Education. Arrangements will be completed to offer a Master's degree in the Department of Mechanical Engineering within the next year. The number of graduate students is small at the present time but prospects are indicating a considerable increase in the coming year.

No. 120. There has been a slight change in the number of graduate courses. Few students have taken graduate work in the past but a new plan of fellowships in the engineering experiment station has increased the graduate work materially. It seems quite probable that this work will not develop extensively beyond those groups which are working upon particular problems in the experiment station which have special significance to the State of Oregon, and who are employed upon a half-time basis. With the development of the engineering experiment station and research work upon problems of significance to the State, the need for part-time assistance and the strength of student interest in research problems will gradually increase the amount of graduate work offered. It will, however, be some time before graduate students will be enrolled in such numbers as to require the organization of graduate classes in specific courses. Graduate work at the present time is carried on with instructors acting as tutors and counselors and because of the ability of those assigned to graduate instruction, it is carried forward at a high level of efficiency.

No. 121. The number of graduate courses has increased only moderately. Graduate students have been restricted in number, and only the best have been accepted. Students from Germany have applied and have been accepted.

No. 124. The number of graduate courses has been somewhat increased and their quality has undergone a systematic improvement. Effort has been made to more nearly correlate the graduate subjects so that they would fall more or less into groups with a definite objective.

No. 126. Graduate courses increased from 24 to 63. Quality improved by more definite organization and greater demand for graduate work. Number of graduate students increased from 4 to 16. Better organization for graduate research. Six part-time graduate research fellowships now available.

No. 128. Each department has added, at different times, new courses both academic and in research work.

No. 129. Graduate courses offered for first time within this period.

No. 130. Graduate work inaugurated this year for the first time.

No. 132. None.

No. 133. No graduate courses offered.

No. 134. There has been a considerable increase in the number of graduate courses offered in the following departments: Mathematics, Physics, Chemistry and Textile Engineering.

No. 135. No graduate courses.

No. 136. No graduate work at present.

No. 137. No graduate courses.

No. 138. Do not give graduate work.

No. 139. The College of Engineering and Commerce and the School of Applied Arts of the university offer opportunities for graduate work in engineering, commerce, the applied arts, and in the basic sciences of those branches, leading to the appropriate professional graduate degrees.

No. 140. No graduate courses offered in engineering. The school is small and no attempt has been made to work up a graduate department. Under Professor C. B. Andrews, work has been started in a small way on soil mechanics. Last year the course was offered in the evening and was elected by a number of practicing engineers. This year the work offered is along the physical science side but next year we plan to offer a course on concrete for practicing engineers. We have only a small number of prospects for such courses and must concentrate on different lines during each year.

No. 141. None.

No. 143. We do not offer any graduate courses in engineering.

No. 145. No graduate work in engineering.

4. GRADUATE WORK; ADMINISTRATION; REPLIES TO QUESTION

Where is the administrative control of graduate work placed and how is it supervised?

No. 2. The planning of the graduate courses was carried out by a Committee on Graduate Study and the supervision of the work is placed with the Dean of the College who is also Director of the Evening Session.

No. 4. Placed in Educational Senate, and supervised by the Committee on Graduate Degrees, consisting of one representative from each college.

No. 5. The control of graduate work is placed in the hands of a Committee on Higher Degrees and the Dean. We give only the Master of Science degree.

No. 10. All graduate work is in charge of a Faculty Committee on ''Graduate Courses and Scholarships''; membership consists of one member from each Department Committee on Graduate Students—about 16 members in all. Dean of Graduate Students is Chairman. Department Committees present recommendations for degrees to the Graduate Committee which, in turn, recommends to the faculty. Committee acts with power on approval of graduate courses and on award of graduate scholarships and fellowships.

No. 11. Committee of the Faculty.

No. 15. With heads of appropriate departments.

No. 16. In the Graduate School, supervised by the Engineering Division which reports to the Dean of the Graduate School.

No. 17. Administration control resides in the Committee on Advanced Degrees and supervision is directed by heads of departments.

No. 18. The administrative control of graduate work is under the faculty of engineering. Each head of a department is responsible to the faculty for the graduate work in his department. In the Engineering School, the department head is in all cases the major professor.

No. 19. The final year of the engineering course is graduate work in the sense that it is taken by students who already have the B.S. degree, but is an extension of the professional course in engineering and is under the control of the School of Engineering. Specialized graduate work in engineering subjects such as is taken by candidates for the M.A and Ph.D. degrees is under the jurisdiction of the Faculty of Pure Science, not under the Faculty of Engineering.

No. 31. We give professional degrees Ch.E., C.E., E.E., M.E., and A.E. for three years' professional experience and a thesis, to such of our graduates as care to do the work.

No. 32. All graduate work, except under 3 above, is at present under the Graduate School of the University, where no degrees in engineering are given. There is one policy, recently adopted, where graduates of other technical schools seeking credit for advanced degrees at their own alma mater, may take courses at the Graduate School here, such as in higher mathematics and physics, and then have such credit transferred to the College or University affected, for recognized credit toward their degrees.

No. 34. The fifth-year work is under the control of the Dean and the teachers having rank of ''Professor.''

No. 36. The only graduate course that is offered at the University is that of the professional M.E., E.E., C.E., or Ch.E. The requirements for this are as follows: Three years after the student leaves college he is required to undergo a special oral examination after writing an acceptable thesis. The administrative control of this course is vested in the Dean of the College of Engineering and the department head who is most concerned with a special examination and preparation of the thesis.

No. 38. The administrative control is through the Graduate School of the University. The actual and technical control of the work is through the department heads of the Engineering and Mines Schools.

No. 39. Graduate work for one year, leading to degree of C.E., E.E., M.E., or Ch.E., is under the faculty of the School of Engineering, supervised by professors of school.

No. 44. Graduate work is under the control of the Dean of the Graduate School, but is under the direct supervision of the head of the department in which the major work is taken.

No. 46. With the Dean and Faculty of the Graduate School.

No. 49. It is under the Faculty and Dean of the School of Graduate Studies.

No. 51. It is under the general and final control of the Board of the Graduate School of Yale University. A special committee consisting of the Chairman of the Engineering Division (the associated engineering departments) and four of the engineering professors acting as a committee on higher degrees have direct supervision of graduate work. To this committee the individual departments report as to the work in their respective departments.

No. 57. No graduate engineering work offered.

No. 62. All of the graduate work in the University is placed under control of the Dean of the Graduate School and the Graduate Committee.

No. 67. The administrative control of graduate work is placed with: The Dean of the Graduate School; the Executive Committee of the Graduate School; the Engineering Graduate Committee; the heads of the departments.

No. 68. Administration in the departments and in the faculty of this college so far as nature and extent of courses are concerned. Registration is with the Dean of the Graduate College. A graduate committee of this faculty composed of all full rank professors has immediate supervision of graduate work.

No. 69. In the hands of the Graduate School of the University. Students majoring in engineering supervised by head of engineering department in which major is elected.

No. 70. Control is in the hands of the Dean of the Graduate School. Supervision by a separate committee appointed to be responsible for each student, so far as work, examinations and recommendations are concerned.

No. 71. None done at present.

No. 74. By faculty of College of Engineering.

No. 75. Administrative control of graduate students is under the supervision of the Dean of the Graduate School and supervised by the professor under which the work is taken.

No. 79. Work is carried on in the separate departments but a graduate student must register with the professor appointed to act as a dean of graduate students.

No. 82. In a Graduate Study Committee.

No. 83. All graduate work of University is under control of Graduate Council, the administrative officer of which is the Dean of the Graduate School.

No. 84. Control is vested in the Dean of the Graduate Division. Supervision is by regular members of the faculty offering courses, under the direction of department chairmen.

No. 85. All graduate work is centered in the Graduate School but each college has, of course, an interest in its own graduate work as well. Each graduate student elects his own committee subject to general supervision of the central committee of the Graduate School.

No. 87. The Graduate School is under the direction of the Committee on Graduate Studies. This committee consists of the Dean of the College of Arts and Sciences, Agriculture, Engineering, Commerce and Journalism, Law, Pharmacy, and Teachers College and the Vice-President of the University. The Chairman of this committee has been the Dean of the College of Arts and Sciences. At the present time only courses leading to the degrees of Master of Science and Master of Arts have been offered. Starting with the college year of 1930–31 there will be an organized Graduate School under full time Dean and courses leading to the Ph.D. degree will be offered.

No. 89. In graduate council and Dean of Graduate School. Back of these the general faculty of the University and the Academic Council. The Academic Council is composed of the Deans of the various schools, President, two members elected from the faculty.

No. 91. The Dean of the Graduate School, the Dean of Engineering and the head of the department concerned arrange the program for each graduate student. The work in each course of study is supervised by some individual member of the staff selected by the head of the department.

No. 93. The Dean of Graduate Study is administrative head. Graduate faculty and head of the department concerned supervise the work. The Dean of the college concerned recommends the candidate for the appropriate degree.

No. 95. Graduate School. Dean and Executive Committee. Committees for various groups of subjects (as "Physical Sciences and Mathematics").

No. 96. The graduate work is under the control of the faculty as a whole. The outline for the graduate year is planned by the department and adopted by the faculty so that all students pursue a regular curriculum. None of our advanced engineering work is taken under the direction of the Graduate School. Our graduate year is outlined in the same manner as the undergraduate with regular advanced subject matter and about forty to fifty per cent elective.

No. 97. A graduate college Dean, administrator. A graduate college faculty, nominally in control, but seldom meeting. A graduate council created by the faculty, and acting in the double capacity of a legislative body and an executive body. It establishes rules of procedure and standards of excellence. It passes upon the sufficiency of courses for graduate rating. It approves or disapproves for graduate instruction the personnel recommended by departments. Departmental graduate committees (*e.g.,* Engineering) which examines proposed student programs and recommends approval by Dean when satisfied that the complete program is of proper grade and homogeneity. Departmental adviser, appointed individually for each graduate student.

No. 98. Graduate Committee.

No. 99. Graduate work is offered, under the supervision of the Dean of the Graduate School, by competent members of various departments of instruction and research. These members constitute the faculty of the Graduate School. The general administrative functions of the faculty are delegated to the Dean and the Council.

No. 100. The administrative control of graduate work is placed in the Graduate School and the work is supervised by the professor under whom the major is carried.

No. 101. Graduate Council headed by Dean of Graduate School.

No. 102 University Committee on Graduate Work, supervised by department heads.

No. 104. Committee on Graduate Study.

No. 105. At present under a committee on graduate work for general supervision. Direct supervision by the college. The Graduate School is in the process of reorganization and all engineering work will be included in the industrial and science group. A chairman for this group has been elected effective 1930.

No. 106. By a graduate faculty and a Dean of the Graduate School.

No. 107. Graduate Committee. Major professor.

No. 111. In the Dean of the Graduate College with a committee in the Engineering College to correlate with the Graduate College. Essentially the character of the graduate work in the College of Engineering is directed by the Dean of Engineering.

No. 112. Administrative control of graduate work lies with the Graduate Council. Programs for graduate students are prepared by the major instructors under general regulations prescribed, and are subject to approval by the Graduate Council.

No. 113. Graduate Committee.

No. 114. Committee on Graduate Study. Dean of school. Head of department.

No. 115. The administrative control of graduate work is in the charge of a graduate committee.

No. 117. Dean of Graduate School, Graduate faculty and head of department in which student majors.

No. 119. The administration of the graduate work is invested in the Dean of the Graduate School, who is responsible for setting the standards of the work of the department. Each department is responsible for building up its curriculum and seeing that the necessary courses are offered. The Dean of the Graduate School has an Advisory Committee consisting of a representative from each of the six divisions in the college offering graduate work.

No. 120. The control of graduate work is placed in the hands of a graduate committee but the responsibility for the thoroughness and efficiency of it remains with the department in which the degree is received. The standard of graduate work has been raised by the supervision in the Engineering School and by a common policy accepted within that school.

No. 121. The Graduate School consists of those who offer accepted courses in graduate study. The Graduate School, presided over by a Dean, passes on graduate courses and approves recommendations for degrees.

No. 124. The Dean of the Graduate School supervises the graduate work with the advice of the Graduate Council.

No. 126. Control in committees of six members—"Committee on Graduate Programs and Degrees." This committee unifies practices; encourages and passes an offering of courses; passes on programs of study of graduate students; and recommends granting of degrees.

No. 127. The work in the Graduate School is carried on under the supervision of the Committee on Graduate Studies. This committee is headed by the Dean of the Graduate School. The Engineering College has one member of this committee.

No. 128. In a Faculty Committee.

No. 129. Supervised by the head of department concerned.

No. 130. Graduate Committee, to whom heads of departments giving graduate work are responsible.

No. 132. Under head of department in which the degree is to be secured.

No. 133. No graduate work offered.

No. 134. The graduate curriculum is under the control of a committee consisting of the Dean, Registrar, and the heads of the degree-granting departments. The head of each department supervises the work of his own department.

No. 136. No graduate work at present.

No. 137. No graduate work.

No. 139. In addition to the usual research work in connection with the various departments of the College of Engineering and Commerce and the School of Applied Arts, an Institute of Scientific Research has been organized in which to carry on definite types of research work of fundamental character connected with basic industries. At the present time the Institute of Scientific Research consists of five major units: 1. The Research Laboratory of the Tanners' Council of America. 2. The Commercial Club of Cincinnati Research Survey. 3. The Research Laboratory of the Lithographic Technical Foundation. 4. The Basic Science Research Laboratory. 5. The Sound Research Laboratory.

(Quoted from catalogue.)

No. 140. All graduate work of the University is under the control of a committee on graduate work and the administrative work is handled by the Chairman of the Graduate Work Committee. The general committee selects for each candidate a special faculty committee. At present there are no candidates in engineering.

No. 141. None.

PART IV

EDUCATIONAL DEVELOPMENT

1. TEACHING METHODS; CHANGES; REPLIES TO QUESTION

Have any significant changes been made in teaching methods?

NUMBER OF INSTITUTIONS REPORTING SIGNIFICANT CHANGES IN TEACHING METHODS AND EXPERIMENTS IN METHODS *

	Significant Changes	Experiments
Yes	30	26
No	34	32
No Report	37	43
TOTAL	101	101

No. 1. No.

No. 2. None, except through reports of the representatives of the teaching staff who attended the summer session of the S. P. E. E.

No. 4. No.

No. 8. No significant changes in general policy; departmental changes have been made.

No. 10. There have been no outstanding changes in teaching methods; though as a result of faculty discussion and particularly of departmental staff conferences, minor improvements have been adopted from time to time.

No. 11. Courses and methods changing like a cork on water, but the fundamental methods in vogue for 80 years are not deviated from to any extent by any professor.

No. 15. Adoption of divisioning according to ability in freshman and sophomore work—considered successful. Course in elementary engineering mathematics to bridge gap between high school and college work. Same reduction of extent of ground covered in certain subjects in order to provide greater thoroughness.

No. 16. No.

No. 18. None.

---

* Page 522.

No. 25. Many meetings, discussions and conferences. It is felt that individual thought and interest have been stimulated. There is no desire to force changes or establish standardized procedure.

No. 27. No.

No. 31. Several changes have been made which are worthy of note: The work of the classroom is co-related with that of the shop in the following courses: (*a*) Production engineering (this course would be impossible as conducted without co-operative students); this course is largely based on the case problem method with its material drawn to a great extent from the shop. (*b*) Industrial management; the major divisions of this subject, as presented in "Anderson," are worked over by the student by corresponding case problems, the material for which must be again taken from the co-op plants.

No. 32. No changes of significant value.

No. 34. All of our laboratory exercises are conducted as "studies" rather than as "tests." The student is encouraged to increase his confidence in his ability to predict results from a knowledge of his theory and to compare these predicted results with the observations from his laboratory studies.

No. 36. No changes of this character have been made in the last few years.

No. 38. No.

No. 39. None.

No. 42. We have adopted the method of devoting one two-hour period a week to problem and computation work in connection with courses in mechanics, and we may use this method in other courses if it is successful in the mechanics courses.

No. 48. No.

No. 49. In freshman and sophomore courses in English and mathematics, the sections have been segregated on the basis of ability, the "fast moving" sections covering the ground more thoroughly and more extensively.

No. 50. More problem work—less lectures—more design work.

No. 51. There has been a rather definite trend in most of our departments toward placing a greater responsibility on the individual student; the emphasis has been on *learning* rather than *teaching*. More and more "project" work has been introduced, or the student is encouraged to investigate some problem on his own account.

No. 54. The policy of close personal supervision over the work of a small group of selected students characterizes the Thayer School.

No. 57. No significant changes.

No. 62. None.

No. 68. Previous to 1927, supervised study periods were extensively used, particularly in mechanics. These have been largely discontinued because of the cost of that method.

No. 70. Only some minor changes where improvement has been made.

No. 71. None.

No. 74. None.

No. 75. No.

No. 79. Emphasis is laid upon improving methods of teaching but the improvement is generally left to the teacher. A definite plan for improved teaching is being worked out by the faculty.

No. 81. The most significant change made recently has been in the establishment of a Department of General Engineering in 1924. This department consists of the freshman work which is common to all the branches of engineering. It has an administrative head who gives two thirds of his time to his administrative and advisory work with the students, the latter being an important feature. The orientation and problems courses for freshmen come under his supervision. During the past few years placement tests have been given entering freshmen to be used as a basis for sectioning. Resectioning on the basis of ability is carried out throughout the year with considerable success.

No. 82. None.

No. 83. No.

No. 84. Nothing of any significance.

No. 87. There have been no real changes made recently except that more attention has been paid to methods of conducting laboratory work.

No. 89. Juniors and seniors, seniors especially, are expected to, and do, work under less direct leadership of teacher. Placed more on own initiative.

No. 91. No material changes made.

No. 93. We have two honors group courses in electrical engineering. Various minor changes have been made in several courses as a result of the S. P. E. E. investigation. In the departments of chemical engineering and civil engineering the curricula have been altered in accordance with suggestions on the unified plan discussed in S. P. E. E. meetings. (In general we feel that our plan of small classes and individual attention to the student works well.)

No. 94. In addition, constant effort has been made to reduce the numbers, in the section, particularly in freshmen and sophomore mathematics.

No. 96. None that are of sufficient importance to report. During the last two years, the Committee on Educational Policy has given some attention to possible improvements in the quality of teaching; so far, however, while there has been considerable interest aroused in the problem the actual quality of teaching has not been greatly changed. The securing of high class men for the faculty and the promotion of a friendly feeling and free discussion among the members is encouraged.

No. 98. More emphasis on student work and less on lecture instruction.

No. 99. Weekly chemistry and physics demonstration lectures have been added to the regular recitation and laboratory work. Improved results are being obtained. Physics for all technology students has been placed in the sophomore year. In electrical engineering mathematics is being emphasized more in junior problem work. Architectural students are finding the physics that has been especially designed for them more interesting than the physics usually given engineering students. Graphical methods will be used more in teaching these students mechanics in the future than has been our practice.

No. 101. Only minor, except greater attention is being paid to the individual students. Orientation tests serve as placement tests and the results for freshmen are placed in the hands of the instructional staff within three or four days after the opening of the first semester, where they are used for individualization of instruction. Sub-collegiate courses in English and mathematics have been developed for those who have poor preparation.

No. 102. No.

No. 104. No marked changes in method of presenting subject matter.

No. 107. S. P. E. E. Discussions of methods are studied for application to our conditions.

No. 111. Gradual elimination of the "lecture" courses and the substitution of quiz sections. Reduction of size of sections to about 20 in most subjects. Increased emphasis on problem work and project work. Increase in the amount and great improvement in the character of laboratory courses in such subjects as materials of engineering, electrical and mechanical equipment and design.

No. 112. No.

No. 113. No changes made.

No. 115. A more general use of functional situations in which the solution of problems plays an important part. A special effort is made in the assignment of laboratory problems to avoid specific directions in many instances in order to cultivate the research attitude and point of view. A more general use of two-hour problem periods in courses in mathematics and pure and applied mechanics.

No. 117. I do not think so.

No. 119. No.

No. 120. While there has been a general improvement in instruction due to course organization and clarified objectives, there has been no unusual change in teaching methods. Supervised design, computation, and laboratory work have been emphasized at the college for a number of years.

No. 121. The exceptional student has been given more opportunity to exert himself, according to his own initiative and ability by being granted special projects under supervision. This is reserved largely for seniors in the School of Engineering. It has succeeded.

No. 126. Sectioning according to ability in operation in several departments, especially those having large freshmen groups.

No. 127. In the engineering physics courses, in addition to the regular lectures and laboratory work, the students are met in small tutorial sections (12 is the maximum number). The tutorial sessions are 2 hours in length and the work consists of supervised problem solving and quizzes both oral and written. An important point in connection with the written quizzes is that the quiz papers for an entire semester, written on printed form, are kept in a regular card catalogue file.

No. 130. We have been endeavoring, ever since the change in administration two years ago, to place the student more and more upon his own responsibility, in the last two years of the course.

No. 132. None except that the matter at various times has received faculty discussions.

No. 133. Wherever possible we assign two teachers to a class. This is a dangerous expedient, but if the necessary cooperation can be secured, it produces good results. One man, of course, is in charge of the class, and the other attends as a sort of a visitor and assistant. For example, one of the assistant professors attends the class of the department head in analysis of stresses, and is expected to indicate to the department head his opinion of how well the subject is ''getting over.'' Incidentally, the assistant professor has charge of related work, and the department head attends his class as a sort of visitor-critic. When two professors are around, each will be more careful about what he says and does.

No. 134. No.

No. 135. No.

No. 136. None in our first four years.

No. 137. Our method of teaching has always emphasized the recitation rather than the lecture system. Blackboard demonstration by the pupils with the individual attention of the instructor to each student has characterized the method. In such subjects as chemistry, physics, etc., where illustrative lectures are necessary, recitations on the lectures supplemented by an approved textbook are required.

No. 140. None.

No. 141. None.

No. 143. We are striving very hard to reduce the lectures to a minimum and the participation on the part of the students to a maximum. We are advocating in each class in each course a short written quiz every day in the week and as little emphasis as possible being placed on final examinations. A written quiz each day is in line with current outside engineering practice and I need not go into the details of this. It solves many of the questions which arise concerning matters of attendance et cetera with the lower classmen.

No. 145. No.

2. Teaching Methods; Experiments; Replies to Question

Have any experiments in teaching methods been conducted?

No. 1. No.

No. 2. Supervised study in physics—sectioning according to attainment.

No. 4. No.

No. 10. Interesting suggestions have resulted from constant study of the regular faculty committees on graduate courses and scholarships, and on undergraduate courses, and from a recent survey by a student committee. As a result of the latter there has been appointed and operative for two years a standing faculty and student committee for consideration of courses of instruction, teaching methods, etc. This committee's suggestions and findings have resulted in desirable changes. As far as we know this is the first instance of continuous and successful coöperative effort in which the undergraduates have borne so large a share. The operation of ''honors'' groups in some departments has proved very successful. The desirability of extension of this feature is clearly evidenced.

No. 11. No radical experiments.

No. 16. The experiment of having small divisions in mechanics meet informally around a table in place of regular recitations has been tried. The result has not been considered particularly successful as compared with the recitation. A change was made this year in teaching descriptive geometry. Recitations were dropped. One lecture per week followed by two two-hour drawing periods substituted. Results so far very satisfactory.

No. 18. None.

No. 27. True-false system is being tried in several courses.

No. 31. Courses in corporation finance and engineering law revolve largely around the case problem method; one half the scheduled time, approximately, is devoted to theory; the remainder to the application of the theory to case problems, the material for which comes from actual problems taken, largely, from the industrial community from which the student experience has been drawn.

The following experiments are being conducted:

1. Business English, a subject for upper classmen, will use as its material the reports submitted in corporation finance and engineering law.

2. The course in engineering problems will draw its material largely from the industries now coöperating with this institution in the training of engineers.

No. 32. The School of Education undoubtedly could furnish valuable information, but there is nothing new in College of engineering.

No. 34. No.

No. 36. It is not possible with our small staff to make any new experiments in teaching methods of this nature. Therefore no studies of this kind have been attempted.

No. 38. We have been experimenting with visual methods in parts of some courses, and believe this method takes the place of certain descriptive work.

No. 39. None.

No. 42. We have found the inspection trip program mentioned in the orientation of freshman students particularly worth while since we require written reports from the students after each trip. This has been found to stimulate the student's interest in what he sees and makes him more alert during the progress of the trip in getting material for his report.

No. 48. No.

No. 54. None.

No. 57. We have experimented with the objective type of examination to some extent and with fair success.

No. 62. None.

No. 67. We are using the Iowa Placement Tests as follows: Mathematics training, English training, and physics aptitude, and are sectionalizing the classes wherever possible. The following averages on Placement Tests at time of entrance last fall may be of interest in this connection.

	Mathematics	English	Physics
Freshman class	46.62	44.31	66.09
Freshman group who failed during the fall quarter.	32.11	35.44	55.11

No. 70. A committee has charge of general matters relating to teaching and reports periodically to the faculty. Department of Drawing and Mechanism has and is conducting certain experiments. For freshmen who show signs of difficulty in their work attendance is required at a short period course in "How to Study."

No. 71. None.

No. 74. None.

No. 75. No.

No. 79. No radical experiments have been tried. Daily short quizzes have been tried with benefit in some of the larger classes.

No. 81. The most important experiment in teaching method is that of being carried on by Prof. C. C. More and his associates in the field of mechanics and structural engineering. Professor More developed the problem method and started the present movement for freshman problems courses. He is conducting his experiments along this line with remarkable success.

Another noteworthy experiment has been made in teaching freshman drawing. Prof. F. M. Warner uses the first quarter for pencil sketching, lettering, orthographic projections, etc., and the use of drawing instruments is not taken up until the second quarter. His course in descriptive geometry is also handled as a drafting problems course. He devotes only a few periods to the matter of rotation.

No. 82. No.

No. 83. No.

No. 84. None worthy of mention.

No. 87. This matter has been discussed by the Dean and heads of departments. No experiments have been conducted.

No. 89. None other than noted under (1) above.

No. 91. No experiments along this line have been conducted.

No. 93. Lectures on teaching methods by the head of the Department of Psychology have been given before the engineering faculty. Various teachers have tried and are trying out various expedients and methods in teaching. We are experimenting with the honors group plan. We discuss teaching methods in our local S. P. E. E. meetings.

No. 95. An experiment in class size in mathematics has been undertaken; not completed. (Another one in physics showed no advantages or disadvantages to justify conclusions, in my opinion. Published by Earl Hudelson.)

No. 96. In certain subjects in the Mechanical Engineering Department an attempt is made to provide for the progress of the other members of the class. In order to do this a considerable portion of the work is based upon individual assignments in which general principles are stated and illustrated, with necessary references, problems assigned and questions asked to direct the thought of the student. The student is required to make a definite plan of procedure before beginning on his problem and makes a report when he has finished. New problems are then assigned. Requiring a definite plan of procedure reduces errors, saves time, and enables teachers to handle larger groups. An extension of this experiment is contemplated. The case or project method is largely used in civil engineering.

No. 98. No.

No. 99. A laboratory period in mechanics has been used for three years, in which students work problems. This has not seemed to be an advantage and is being discontinued. Advanced mathematics is being given to a selected group of juniors in electrical and mechanical engineering. This is proving helpful in teaching mathematics to sophomores since the upper classmen are using their mathematics to a greater extent in their engineering work. Freshmen are classified for mathematics by the Iowa tests and sectioned into three groups—fast, medium, and slow. The three groups cover the same ground by meeting in class four, five and six hours per week respectively. Success of plan not established. Instructors about evenly divided for and against it.

No. 101. New grading system. Special attention to superior students. Studies in teaching methods. Semester examinations. Student personnel studies. Studies of freshman placement tests. Experiments with double-pace sections. Orientation of freshmen. Studies in higher education VII and IX include additional information.

No. 102. No.

No. 104. No.

No. 105. Several years ago a freshman section was formed for those who were found to be very slow or deficient in mathematics. The number of recoveries at first seemed promising, but time proved that such a small percentage made good, that the plan has been discontinued.

No. 106. Sectioning on the basis of ability has been tried in the Departments of Mathematics, Mechanics, and Electrical Engineering. The practice has been discontinued in mathematics and mechanics but is still in use to a limited extent in electrical engineering. All freshmen in the university take elementary English. In this course, the students are placed in A, B, and C sections, according to ability and previous training.

No. 107. No.

No. 111. No.

No. 112. None that appear to be of importance.

No. 113. No.

No. 115. Experiments are under way to determine the relation between class-size and teaching efficiency. The tendency is to increase the size of classes. Experiments with two-hour problem periods in mathematical subjects have proved very satisfactory. The Purdue rating scales for instructors have been used with significant and beneficial results especially when all staff members of a given department have coöperated in studying the results of the student ratings.

No. 117. Not in School of Engineering.

No. 119. No.

No. 120. No controlled experimental work has been done in teaching methods. The freshman engineering part of instruction has, however, been a very satisfactory demonstration. The schools have been very stimulating to the improvement of instruction in the courses of those who have attended and have introduced the study of instructional methods to the entire staff through the reports of those returning from them.

No. 123. No organized or large scale experiments. Individuals and departments have been trying problem courses. Use of computing periods, etc.

No. 130. Less lecturing, more studying. Results satisfactory.

No. 132. None.

No. 133. None.

No. 134. No.

No. 135. No.

No. 137. In some of the senior work we are substituting the lecture system in a few courses.

No. 139. None.

No. 140. The text and methods in mechanical drawing have been changed this year. It is still too early to say whether the result will be satisfactory but it appears to be meeting the requirements. In some of the senior courses, we have tried the scheme of giving the students a general topic and meeting the group at infrequent intervals (something like honors courses). This has not been particularly successful and the regular tri-weekly meeting seems better. We have also assigned different men to take charge of the class group on different days and to handle the topics assigned for that day. This has been more successful than the other method.

No. 141. None.

No. 143. We are experimenting at the present time with the question of instruction in alternate periods rather than with continuous instruction. We believe that the examinations at the end of the period to be worthless. We are, I think, finding that emphasis on a few fundamental things is sound, but the multiplication of technical applications is absolutely unsound. We experiment concerning the teaching of mathematics, especially calculus, and we are giving most of our calculus at the present time as a part of our course in analytical mechanics. Again, it seems too simple to mention, but there seems no way to force young and immature students to form abstract concepts or reason abstractly. We are beginning to feel that the method of alternate periods of instruction has some very definite and lasting advantages over a continuous method. A continuous method, is, we believe, somewhat akin to cramming and if the course is lengthened somewhat and given an alternate period, a professor or instructor is forced to good teaching methods, and the student gets something which he retains certainly a few weeks after the final examinations of the subject.

Our experiments seem to have proven that it is a huge joke to test a man's ability within a day or two after the course is finished and indications would point to the fact that, if his ability were tested five years after the end of the subject, he would retain mighty little of it under our present method of instruction.

No. 145. No.

3. TEACHING LOAD *

NORMAL TEACHING LOAD OF ENGINEERING TEACHERS EXPRESSED IN TOTAL CLOCK HOURS (CLASS PERIODS OF FIFTY TO FIFTY-FIVE MINUTES EACH) PER WEEK IN ACTUAL CONTACT WITH STUDENTS IN CLASS OR LABORATORY

(Data from 89 Institutions)

	Clock Hours per Week		
	Max.	Aver.	Min.
Department Heads	22	13.2	6
Professors	28	15.4	10
Associate Professors	30	16.3	10
Assistant Professors	32	17.1	9
Instructors	30	17.6	6

---

* Page 313.

4. Salaries of Engineering Teachers *

Data from 66 Institutions—Dec. 31, 1929

	Number of Insts.	Number of Cases	Maximum Salaries		Average Salary	Minimum Salaries	
			Highest	Average		Average	Lowest
Administrative Officers (Incl. Dean)	58	103	15,000	6,540	5,540	5,330	3,000
Department Heads	51	350	9,000	4,880	4,430	3,845	2,800
Professors	52	447	8,000	4,630	4,230	3,660	2,750
Associate Professors	54	307	6,000	3,575	3,370	3,165	2,200
Assistant Professors	66	578	5,500	3,115	2,745	2,515	1,850
Instructors	65	778	3,500	2,490	2,050	1,845	1,000
Assistants	44	228	2,200	1,190	965	800	75

* Page 309.

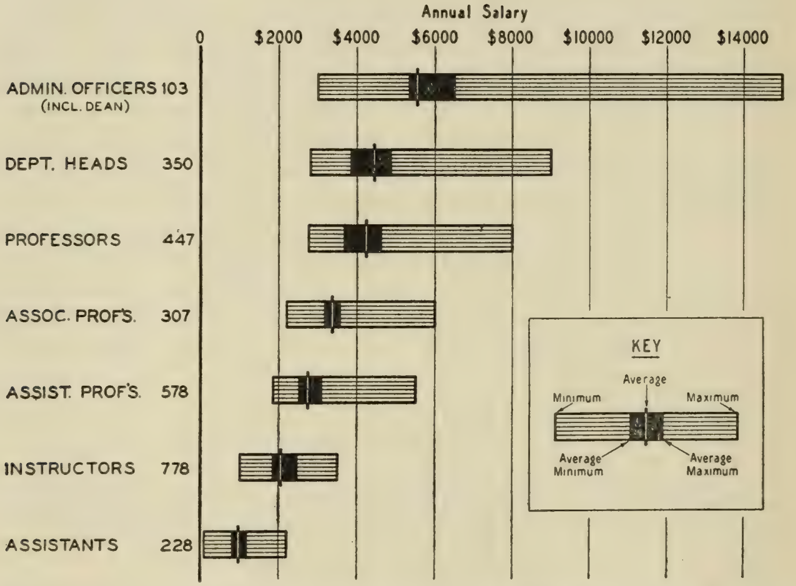


Fig. 4. Salaries of Engineering Teachers in 66 Institutions—Dec. 31, 1929

5. Research and Publications *

Number of Institutions Reporting	80
a. Number of Research Fellowships	234
b. Number of Part and Full Time Assistants	511
c. Number of Published Bulletins	600 (Approx.)
d. Reported Expenditures for Research	$1,301,871

* Page 330.

A complete report of research in engineering colleges has been prepared under the direction of Dean R. A. Seaton, Chairman of the Committee on Research, and is published as a supplement to Vol. XXXI, No. 6, JOURNAL OF ENGINEERING EDUCATION.

6. S. P. E. E. SUMMER SCHOOLS *

(*a*) Expenses; Replies to Question

Has your institution defrayed any of the expenses of the representatives to these schools?

Forty-five per cent of the institutions reporting defray the expenses in whole or in part of their representatives at the S. P. E. E. Summer School.

(*b*) Value; Replies to Question

What is your impression as to values received by those who have attended the Summer School?

No. 1. Very good.

No. 2. Very much worth while, inspiring.

No. 4. Very useful and got a great deal out of it.

No. 5. Marked value.

No. 7. The institution has defrayed all expenses. Good contacts for the younger instructors. However, it seems that the summer schools are attended too largely by professorial talent and not largely enough by instructors.

No. 8. Very great.

No. 10. Excellent.

No. 13. Three men attending last summer found the courses valuable.

No. 15. They are very considerable and well worth the effort.

No. 16. Decidedly advantageous. Stimulating interest and inspiration.

No. 17. As far as we have observed, this work has been very helpful.

No. 19. Each of them has expressed himself as believing that his time was spent to very great advantage in the summer school.

No. 27. Sufficiently great to warrant especial emphasis upon its continuation and our attendance.

No. 32. Favorable in every instance. Would encourage attendance by all eligible.

No. 33. They are very much worth while.

No. 36. It is my impression that teachers who have attended the special summer school work have been helped and given a new out-look in their teaching profession. Contacts made in changing work are not only helpful but very desirable. It is my belief that such summer schools courses should be greatly strengthened and improved, though this is not a criticism of former summer schools.

---

* Five sessions during three summers had been held when the questionnaire was issued.

No. 38. Most valuable.

No. 39. Great value.

No. 44. By the contacts with other instructors and the interchange of ideas on teaching, our faculty members have been more than repaid for the time and expense incurred.

No. 46. Benefit derived from lectures relatively small. More desirable to have expert teachers conduct model classes. Personal contacts with men from other institutions regarded as the most valuable feature.

No. 49. One member of our faculty seems to have been stimulated by the experience.

No. 51. They seemed to get a good deal of inspiration from the experience; new points of view; and profited by meeting others working in their field.

No. 52. Never attended.

No. 54. Very well worth while.

No. 57. Was valuable for the instructor who attended last summer (1929).

No. 61. The schools are felt to be of very considerable value, both from a technical and inspirational standpoint.

No. 62. We believe that the teacher is greatly benefited and that this is reflected in his daily class work.

No. 63. Those who have attended have most favorable reports and the impression is that they are well founded.

No. 67. Very good.

No. 68. Benefit has been general rather than specific.

No. 69. Of very great value.

No. 70. Favorable.

No. 72. We have had one man attend an S. P. E. E. Summer School. He returned amply repaid for the expense and trouble of the trip.

No. 75. The attendance upon the meetings has been the main source of keeping in touch with progressive educational policies. The reports of the Board of Investigation and Coördination contains a comprehensive group of facts which are invaluable to Engineering Education.

No. 79. Very beneficial.

No. 83. Perhaps of some value to the man who goes. Doubtful whether others have benefited.

No. 84. Many points of help; contacts with others gave ideas to our attendant, although the subjects discussed were not in his line. He believes the schools are very helpful.

No. 85. Excellent. We endorse the plan heartily.

No. 87. Believe much may be gained by attending the summer schools.

No. 89. Very much worth while.

No. 91. Excellent results. More men should go.

No. 93. The time is well spent. Teaching has been improved and those who have attended given greater confidence in our own methods.

No. 95. Very much worth while.

No. 96. That they are not permanent.

No. 97. I am gratified by the enlivened interest in methods, in particular. Our instructors are urged to attend, if practicable.

No. 99. Willing, but in their regular fields of work instructors have outside employment during the summer and feel that they cannot afford to miss this opportunity to add to their yearly income.

No. 100. Many new points were obtained by both teacher and student who were in attendance from Ohio State University. At Purdue the work was considered valuable, especially that done in committees.

No. 101. Very gratifying.

No. 105. Very favorable.

No. 106. Of very considerable value. General in effect rather than specific.

No. 107. Values received are well worth while.

No. 111. Have no information.

No. 112. Reports of those of our faculty who have attended the schools have been favorable and in most cases enthusiastic. I regard the schools as of great value.

No. 113. Personal contacts with men conducting summer sessions and discussions with men from other institutions.

No. 114. Very beneficial.

No. 115. Two members of the engineering staff have attended the summer schools at their own expense. The reports are especially favorable and other members of the staff have been urged to attend the summer schools.

No. 118. The institution has been represented every year at individual expense. The above together with fact that we shall be represented at both sessions for 1930 indicates our favorable opinion.

No. 119. Worth much more than the expenses involved.

No. 123. Excellent. Representatives at two schools have rated them as very valuable.

No. 124. Have been very valuable in offering suggestions of improved methods both by means of lectures and by contact with those in attendance.

No. 126. Of inestimable value.

No. 127. Those members of our engineering faculty who have attended the S. P. E. E. Summer Schools have been very much pleased with the benefits received.

No. 130. We are sending a man to Pittsburgh and believe results will justify the expenditure.

No. 132. Good, members attending have been pleased.

No. 134. Favorable.

No. 136. They are very much worth while.

No. 137. The contact with others and the work done has greatly benefited those who have attended.

No. 138. Very valuable.

No. 141. Very worth-while. Will have representative present at all future schools.

No. 143. So far as I can understand, results have been very good indeed. Several of our men attended last year.

No. 145. None has attended.

PART V

GRADUATE PLACEMENT AND DEMAND

1 (*a*). METHODS IN PLACEMENT OF SENIORS

Number of Institutions Reporting	89
Personnel or Placement Officer	31
Dean or Similar Administrative Officer	27
Department Heads	79
Institutions Using One Method Only	47
" " Two Methods	36
" " All Three Methods	6

1 (*b*). PLACEMENT RECORDS; REPLIES TO REQUESTS FOR

Brief statements of types of records kept for placement purposes.*

No. 1. Card Index System kept by Executive Secretary, Alumni Association.

No. 2. Following data for each position. 1. Name of Company. 2. Address of Company. 3. Man to interview. 4. Type of position. 5. Salary. 6. Qualifications. 7. Remarks. 8. People sent and their findings.

---

* Page 235.

Record of Applicant. Name, address, telephone, class, course, type of work desired, minimum salary, experience, remarks, positions sent to and findings.

No. 4. The usual statistical information is collected from every member of the senior class, including an Employment Information Sheet from which seven or more blueprints are made. These blueprints are for distribution to the personnel representatives who visit Carnegie, or to send out through the mail to companies who wish to correspond with the graduates. The information sheet includes such items as name of student, course taken, college and home address, date of birth, nationality, physical defects, if any; how summers were spent, any experience with firms, student activities, other colleges attended, etc.

The faculty members rate the student according to the specific kind of work for which he is fitted. A member of the Bureau, by means of an Interviewer's Blank, rates the student according to his character, his appearance and address, whether or not he is convincing in conversation, whether he is likely to succeed in business, and whether reports from previous employers and members of the faculty are favorable, unfavorable, or uncertain. Scholarship and psychological test ratings are also available.

No. 5. Each department keeps such records as it desires.

No. 10. In addition to the usual scholastic records, Heads of Departments and Registration Officers of courses kept regular files (usually card records) giving personal characteristics, notes of special qualifications or handicaps and connection with undergraduate activities. These records are available to the Alumni Placement office.

No. 11. None. President's secretary takes this work during the year. Scores and perhaps more than one hundred great corporations and others send personnel officers here between February and June each year looking for members of the graduating classes.

No. 15. Scholastic record detailed and averaged. General acquaintance with extra-curricula activities. Department members' reaction as to personality.

No. 16. None.

No. 17. Personnel records and collegiate grades are available in certain departments for placement purposes.

No. 18. A student qualification record card is filed in the personnel office giving student's name, age, nationality, residence, languages read easily and spoken easily, student activities participated in, class record, opinion of the interviewer, aptitude and interest, practical experience had, and, altogether, the information usually sought by personnel managers in industry.

No. 19. No special records kept. File of letters of prospective positions open in the year for recent graduates and also for those out longer.

No. 24. None kept.

No. 26. In the Dean's office is kept a card file of all Engineering School graduates, giving name, address, class and occupation—kept up to date by a yearly card sent out to each man and by the graduate bulletins. There is also a special card kept for each man who indicates that he wishes to be notified of positions for which he might qualify.

No. 27. Students' academic record kept on file together with data covering any practical experience he may have accumulated, and instructor's impression of his attitude, interest, character, and extra-curricular activities. Also a follow-up of progress or change in work or advancement in rank and salary. This latter record is voluntary on the part of graduates but a request to which they have eagerly responded.

No. 31. Records of shop work as coöperative students, together with class grades, are available for placement of seniors.

No. 32. Our blank is much like the typical blank used by companies. On one side is space for scholarship records, character ratings, and the estimates of various professors. The other side is for the student himself to fill out and includes identification material, space for picture and place to describe the job preferred. A copy of this blank is attached.

No. 33. We keep very complete records of both scholastic achievement and coöperative work. A detailed account of the type of job, kind of work done, report of the employer, and similar data, cumulative over the five-year period, becomes available at graduation for purposes of vocational guidance and placement. Thus the personal qualifications, aptitudes and abilities of each student are quite definitely known which makes the problem of placement much less difficult than would otherwise be the case.

No. 34. File records.

No. 36. The Engineering Department itself keeps no records for placement purposes for several reasons. First, all of our graduates are employed immediately after all commencement activities are over. Those who are temporarily out of a position write in to the Dean of Engineering who informs them of any position that may be open. He himself gets this information from the companies who are constantly requiring new help. Second, a placement bureau is being started under the administration of the College of Education. This has not functioned long enough for us to see whether or not it is entirely successful.

No. 38. Optional with department heads. He arranges the conferences between employers and students.

No. 39. Our regular scholastic record cards with additional cards in office of Dean giving professional record of graduate. The Personnel Director has record blank of his own.

No. 46. No special type of records. Prospective employers hold personal conferences with Dean or with department heads.

No. 48. No special records kept for placement purposes. Regular records consulted when necessary.

No. 49. Scholastic records on file in office of Registrar (copies in office of Dean), and individual record cards showing details of career following graduation, the latter maintained by Alumni Representative on the basis of periodical questionnaires sent to graduates.

No. 51. Full records of mental and scholastic aptitude rating. Scholarship, extra-curricular activities, work for self-support. General personnel rating by instructors.

No. 52. As this is a coöperative college, placement is an undergraduate, as well as a graduate, problem. Careful records are kept throughout the student's course of all data bearing on placement. Pre-college industrial experience is recorded at the outset. Entries are made throughout the college course on the basis of reports received each five weeks from the student's employer and from the student himself. In addition, we keep a record of the interviews of the student with the personnel officers. His vocational interests are checked frequently and recorded. After graduation an annual check is made of the positions occupied by alumni.

No. 54. Positions are offered to graduates on the basis of personal knowledge of the student and his special aptitude. We do not make any organized attempt to place men after their first position. It is not necessary.

No. 57. Records of all seniors (some begin in Junior year) kept at placement bureau, opinions of faculty and fellow students, academic and extra-curriculum accomplishments, personal characteristics and preferences are recorded.

No. 61. Our numbers are so small this is not necessary.

No. 62. Our record of coöperative work done by the students shows the name of the employer, the type of work done by the student, the length of service, the amount of pay received, and the employer's estimate of the student's ability.

No. 63. A placement officer of Tufts College has been recently appointed. As yet he has had little to do for engineers. The records of the Dean's office are available and through his secretary had been constantly useful. The chief responsibility rests on the department heads who handle the matter on the basis of personal acquaintance.

No. 67. Scholastic records and personal qualification records made by faculty members.

No. 68. Rating of each student by three instructors on personal qualities: (1) habits, (2) popularity, (3) address, (4) mental calibre, (5) self-reliance, (6) industry, (7) speed, (8) accuracy, (9) reliability, (10) initiative, (11) forcefulness, (12) judgment. Record also of physical defects and of peculiarities.

No. 69. None other than standard student records.

No. 70. A one-page (or both sides of an 8 × 5 card) personnel record is kept—photo, scholarship, personality, etc. Each professional department keeps its own records, and almost entirely handles the placement work for its seniors.

No. 71. With small classes no ''system'' is needed for record.

No. 74. None really necessary. We have thorough personal acquaintance with every graduate.

No. 77. None.

No. 79. No detailed records kept. An alumni directory is published every few years, but this gives only the present positions of those whose address is known.

No. 82. Registration form on which the student lists information regarding age, degree, experience, major and professional work, and faculty references. Reference forms on which the major professor, supervisor of practice teaching, and general references give estimates of the student's ability. Note: The records refer to the placement of teachers as that is the only form developed as yet.

No. 83. Personnel cards (attached).

No. 84. Mining—personal records in Dean's office. Mechanical—personal records, personality records and grades, scholastic records, etc. C. E.—personal and scholastic records. In the Alumni Bureau of Occupations, quite a complete record of those who are there listed, letters of recommendation, etc., and a perforated card system for ready selection of those listed in any group or occupation.

No. 85. We have a fairly fully developed personnel and placement bureau.

No. 87. List of graduates, where and by whom employed and a list of employers interested in our graduates.

No. 89. High school record. University scholastic record. University extra-curricular activities record. Record of employment during vacation.

No. 91. A simple record sheet is made out by each senior at the beginning of the year. This record sheet is also kept as a permanent record after graduation, being brought up to date from time to time.

No. 93. Scholastic records. Outside activities. Personal characteristics. Opinions of teachers regarding student.

No. 94. Each department head keeps in contact with outside sources, and with the graduates. Arrangements are made with a number of large companies for interviews between their representatives and seniors.

No. 95. Scholastic records. Evaluation by faculty members.

No. 96. Photograph; degrees; major interests; college and home addresses; personal data; high school information; college information; practical experience.

No. 97. Personal and scholastic. Experience, general and technical. College activities, clubs, etc. Activities as a citizen. Preferred employment. Current salary (subsequent to graduation).

No. 98. High school and college records. Photograph. College activities. Vacation activities in part. Intelligence test scores.

No. 99. Use made of scholastic record, in which is kept record of class and extra-curricula activities of student. On account of having small classes and heads of departments meeting men usually for three years in classes, detail records of many characteristics of men are not made.

No. 100. In one department Qualifications and Characteristics records of upper-classmen are obtained from their instructors and student associates. Some departments obtain a complete report from the industry where the student has been employed during vacation periods. In several cases the departmental faculty consider the qualifications of individual students for certain positions which have been offered. All departments keep records of demands.

No. 101. A composite record of each student's personality ratings, scholastic record, health record, intelligence test, practical experience, student activities, vocational preference and other general information is kept for every engineering student. Detailed material is kept in a record folder and the composite is made on a 5 × 8 personnel card for use of employers and teachers. Copies of the personnel records are furnished to the heads of the various schools and departments regularly.

No. 102. None kept.

No. 104. Personnel information about Engineering students available in Dean's office.

No. 105. All correspondence and calls relating to employment are kept on file and are available for student reference. An annual letter is sent out to alumni and former students and a card catalog file is kept of addresses, positions held, etc.

No. 106. Scholastic record. College activities. Outside experience. Earnings during college course. General opinion of senior instructors as to personal characteristics. General nature of work preferred (in some departments).

No. 107. Regular file.

No. 111. Engineering Personnel Leaflets. Interview and Placement Record. Note: Beginning next year, we will use a rating sheet for each senior. These will be filled out by heads of departments and members of the teaching staff.

No. 112. (Character and Personality Record attached.) Form used by electrical engineering department. Most departments employ similar card records.

No. 113. No specific records kept.

No. 115. Ratings—placement tests of freshman week. Scholarship record. Personality ratings. Health record. Record of membership in student organizations and offices held.

No. 117. Records of students in each department kept by head of department.

No. 118. Aside from scholarship records no records are made. Members of staff know every senior intimately. Each member of staff is requested to report on seniors. Estimate of each senior determined by staff conference after individual reports have been filed. Estimates are filed for future reference.

No. 119. No permanent placement records are kept in the Division of Engineering, however, the Secretary of the Former Students' Association is entrusted with keeping a thoroughgoing set of records of the men and positions which are open from time to time.

No. 120. The records kept for placement purposes are just in the process of organization and development. They will be very similar to the American Council personnel sheet with the addition of a sheet for the alumni records which will give specific information regarding employment and address.

No. 121. For assistance of industrial representatives and for our own use, we have a personnel record system, copy of which is enclosed.

No. 123. Senior classes in each department number from 12–20. Small enough so that the need for special records for the purpose has not yet been felt. The department head has two years of rather close contact with each individual.

No. 124. These are kept by the different departments and have not been standardized. In the larger courses, instructors are asked to rate seniors on industry, initiative, personality, and similar characteristics and this is kept on file.

No. 126. No special records for this purpose.

No. 127. Recent photographs. Record of grades made during entire college course. Record of practical engineering experience. Record of college activities. Record of personal history. Rating by three professors on scholarship, industry, initiative, accuracy, self-reliance, common sense, personality, appearance, and resourcefulness.

No. 129. Our placement bureau, in charge of one of our professors, maintains a clearing house of information regarding positions and aids the graduates, whether recent or of former years, to find satisfactory positions. Throughout the year the bureau keeps in touch with the industries so that each graduate may have an opportunity at the end of his course, to consider several openings. A card record is kept showing positions available, students recommended, names of students interested in securing employment, and dates on which they will be available.

No. 130. Interviews and correspondence with industrial departments and research divisions.

No. 131. No formal records kept. The school keeps in touch with alumni and has an employment record of each.

No. 132. No definite system but results have been effective

No. 133. The number of graduates is so small that all of the four professors have complete first-hand knowledge of every man. For our files we keep a biographical sketch of each student, prepared by the students themselves, along with grades and a card on which the composite opinion of all professors in the college who have taught the men is given with regard to such qualities as initiative, personality, leadership, etc.

No. 134. Seniors are graded by several of their professors on personal qualities—a composite rating of these qualities is then put on the record cards of the students.

No. 135. Contacts with industry, employment managers visiting institutions.

No. 136. Nothing permanent has been done in this matter as our first graduates were turned out last June.

No. 137. A full record of each student is kept on file and all information for placement purposes in the office of the registrar. The heads of departments consult these files.

No. 138. In connection with the coöperative work, the student and employer submit periodical reports regarding the outside work. Some students are retained by their employer after graduation.

No. 139. The College of Engineering and Commerce is on a coöperative basis, and we have a coördinator for each department of Engineering. The records give a detailed statement of the practical experience which a student has procured; also the employer's ratings on the various jobs held. It indicates, too, his class standing, his activities in student affairs, his physical record, and a brief statement of his history prior to his entrance to college.

No. 140. Each graduate is listed and a record kept of their employment. As the number is still very small this office is acquainted with the individual and knows his ability.

No. 141. Personnel blanks and scholarship records.

No. 143. We have never found any necessity for keeping records for placement purposes. Our students are all placed, most of them, before they graduate and the number of men out of work is extremely small. A case has not come to my attention for the past two years.

No. 145. No records kept.

2. EMPLOYMENT INFORMATION; REPLIES TO QUESTION

How is information of employment opportunities conveyed to seniors and undergraduates? *

No. 1. By personal conferences and notices on bulletin boards.

No. 2. Information of opportunities is sent to suitable applicants on file by mail or telephone. Also by visiting representatives from large industries and corporations.

No. 4. The Bureau of Recommendations invites companies, interested in the graduates from the engineering and industries courses, to send representatives to the University. Another type of contact is made with companies interested in receiving applications by mail. The Bureau itself merely forms the contact between the graduate and the employer, it does not do any particular vocational guidance work with the senior. However, due to the fact that it invites companies and furnishes information to the students, it does control the so-called exploitations of the young graduate by the mere fact that the less reliable concerns are not included on its accredited firm list. The usual information as to salaries, working conditions, promotion policies, etc., is collected by the Bureau and given to the graduates.

No. 5. By department heads, by direct investigation, and through posted notices.

No. 7. By visits from representatives of the leading industries, and individual cases by faculty advisers and department heads, and faculty committee on student relations.

No. 8. By direct contact between seniors and faculty in the several departments.

No. 10. Notices on general and department bulletin boards. Notices to seniors in class. Facilities for contacts of students with visiting industrial representatives.

* Page 250.

No. 11. By personnel men of corporations. By letters filed with President's secretary. By heads of the various departments.

No. 13. Through department heads interviews are arranged with representatives of employers.

No. 15. Letters and notices are posted on special bulletin boards. General notices read to the section as a whole. Individual personal conferences with certain promising candidates.

No. 16. We have no difficulty in placing our engineering graduates. The demand exceeds the supply. Representatives of leading industries and organizations meet the students during the second semester of senior year and present their opportunities by meeting groups and in personal interviews.

No. 17. Notices are posted on bulletin boards. Applications are handed in person to interested students. When personal representatives come on the ground they are shown every possible courtesy to enable them to interview personally all students interested, and inquire into the respective records of these students.

No. 18. Notices are posted on bulletin boards. Seniors are interviewed and opportunities in the professions made known.

No. 19. Notices of positions which are open are often posted on the Dean's bulletin board. Letters from employers are referred to appropriate department heads.

No. 24. Personal interview.

No. 26. Bulletin board notices in corridors. Notices read in class by the instructors.

No. 27. Conferences. Bulletin board. Posters.

No. 31. Department of Industrial Relations makes personal contact with seniors, or recommends names to employers looking for seniors. Undergraduate employment is all handed by this department under the coöperative plan.

No. 32. Like all other schools, we arrange for interviews between the recruiting officers of companies and the seniors. We also have employment bureau which attempts to register the seniors and to acquaint them with opportunities which they have gathered through means of circular letters. Finally, through the coöperative plan we are able to learn of many employment wants and in the latter case transmit the information to students through notices or announcements by one of the professors in class.

No. 33. Approximately 50 per cent of the graduating seniors annually remain with their coöperative firms. A large number of representatives of industry visit the school annually and have personal interviews with members of the graduating class. Every senior is accorded the assistance of his coördinator in finding suitable after-graduation employment; but the responsibility for getting the job rests squarely upon the shoulders of the student. It is not uncommon for every member of the senior class of over 200 men to have secured an after-graduation job before Commencement.

No. 34. By company representatives mainly. Also various companies will write.

No. 36. Approximately from eight to ten companies write in each year concerning our engineering seniors. Six to eight of these companies send representatives who interview our students and pick the best men. In the past we have had little or no difficulty in placing all of our graduates.

No. 38. Through the department concerned. Usually directly from the department head to the individual student.

No. 39. By Dean and personnel director, by personal announcement, by letter from personnel director, by announcement in our daily newspaper.

No. 42. Bulletin boards and oral announcement by professors. The companies that employ large numbers of engineering graduates send their representatives to the campus each spring to interview the seniors and make offers of positions.

No. 44. Opportunities for employment are offered seniors and undergraduates by representatives of the various industries who visit our college at times previously arranged for. These representatives consult our college records and the various department heads, and then hold personal interviews with the students.

No. 46. By announcement in classes.

No. 48. By personal interview.

No. 49. Through bulletin board notices and personal interviews with Deans and heads of departments. Part time employment for undergraduates is handled through Board of Recommendations centered in office of Alumni Representative.

No. 50. Bulletin boards and interviews.

No. 51. The Personnel Bureau gets out regular bulletins stating what firms are seeking men and describing the positions open. From the records on file and in coöperation with the departments of study, the Bureau selects a man or a group of men who appear to be eligible for a particular job, or for any of several jobs, and notifies the student or students. If any of the students is interested, the company or firm is informed of the fact and very commonly arrangements are made for representatives of the firm personally to interview the candidates. The firm may secure more intimate information through consultation with the department chairman. The Bureau endeavors to give the students the fullest possible information regarding the firms offering positions. There is a Yale Graduate Placement Bureau in New York City, which coöperates with the Bureau in New Haven. The New York Bureau concerns itself not only with finding positions for graduates temporarily out of a job, but also endeavors to locate desirable openings for men who may wish to change their location or type of work.

No. 52. Generally through the personnel officers of the Extramural School.

No. 54. Directly by Dean or through medium of representatives of prospective employers who come to Hanover for that purpose.

No. 57. By telephone or note. Opportunities for interviews are arranged by director of bureau. Ninety firms have representatives at the college this year; sixty-five last year. Last year 85 out of 116 registered with the Bureau were placed before graduation. The Bureau also finds term and summer employment for undergraduates; post office Christmas work, etc.

No. 61. By posting of literature on bulletin boards. By having representatives of employers interview students.

No. 62. For graduate employment, opportunities are presented to all of the seniors; those interested may apply. Undergraduates are assigned to coöperative work by the coordinator.

No. 63. Largely through the Secretary to the Dean and by department heads.

No. 67. By personal conferences and through the visits of industrial representatives.

No. 68. Bulletin board and conference with heads of departments.

No. 69. Through verbal and bulletin board announcements, circular letters, personal conferences.

No. 70. Information published on regular bulletin boards and also in ''Official Bulletin'' in the *Michigan Daily.* Some departments keep special files open at all times to inspection by students. Preliminary contacts are made in some cases at the end of the first semester, by sending out to prospective employees records, photos, etc., of men who will graduate.

No. 71. Through personal interviews.

No. 74. Personal conversations, and also bulletin board notices, announcements at engineering society meetings, and correspondence.

No. 79. From companies which send a personnel agent to the school. From direct application from companies for men. An employment bureau is being formed with a stenographer in charge of records and addresses so quicker connections can be made when a call for a man comes in.

No. 82. The school authorities write to the Appointment Bureau listing vacancies which they wish to fill. The Appointment Secretary then recommends those graduates fitted to handle the type of work described. The school officials may choose among several candidates qualified.

No. 83. By interviews, letters and personal visits.

No. 84. By personal communication, either oral or written, by statements to senior classes (College of Mechanics especially), by posting notices on bulletin boards in the different buildings, and by listing opportunities with the Alumni Bureau of Occupations. The student branch members of the founder societies are urged to list their names with Engineering Employment Service in San Francisco.

No. 85. By bulletins, usually, but we depend mostly upon representatives of industry who visit us.

No. 87. By personal contact between instructors and students. By bulletin boards. Notices in the daily bulletin.

No. 89. Lectures by representatives of corporations. Talks by faculty members. Talks by outside engineers.

No. 91. By personal interviews and talks to the senior class.

No. 93. Bulletin boards. Announcements in classes. Recruiting visits of company representatives.

No. 94. By department heads.

No. 95. Posted notices; talks by employers' representatives; conferences.

No. 96. Bulletins and through department heads. Also visiting representatives of industry.

No. 97. Bulletin board, class notices, direct contact. Rather informal, as a whole.
No. 98. Personal conference with professors.
No. 99. Bulletin boards and visits of company representatives.
No. 100. By department heads—either individually or by posting information on bulletin boards.
No. 101. Information of employment opportunities is conveyed to the seniors: 1. By representatives of industrial concerns visiting the campus and interviewing the seniors. 2. By the Personnel office of the Schools of Engineering through collected information over about eight hundred concerns, and interviews with seniors and undergraduates concerning employment. 3. Through teachers and administrative officers. 4. Through surveys of employment and return by the company of information and request for recommendations.
No. 102. Directly or indirectly through the department heads.
No. 104. Dean or department heads.
No. 105. Through department heads and bulletin boards.
No. 106. By talks from faculty and largely by literature and explanations from representatives of industries. Also by bulletin boards.
No. 107. Bulletin board and personal contact.
No. 111. Personal interviews with heads of departments and personnel officers. Illustrated with lectures by representatives of industrial concerns. Booklet, pamphlets, catalogs, etc., available in the Engineering Personnel office. Personal interviews with industrial representatives who visit the campus. Senior inspection trips.
No. 112. Personal interviews, seminary talks, bulletin boards.
No. 113. Personal consultations.
No. 114. Through bulletins. Public announcements and visits by representatives of industry.
No. 115. By a centralized-decentralized personnel and placement bureau. By department heads. By bulletin board announcements.
No. 117. Nearly all our seniors are engaged by employers or their representatives who visit the college and interview them. If any are not placed before graduation, they are usually placed by head of department, who gives them information at their home addresses, or wherever they may be. Students who wish to make changes write to head of department.
No. 118. Through Dean's office or department heads.
No. 119. Through announcements during lecture periods and posting of notices on the bulletin boards.

No. 120. Graduates are informed concerning employment opportunities by the heads of the respective departments. When representatives from large companies employing men of several departments visit the campus, appointments are made and scheduled by the Dean's office.

No. 121. A calendar of coming interviews is posted. Heads of departments announce and give information about companies coming to interview or those writing for applicants.

No. 123. Usually by announcements made in class periods. It is customary to use some time in making announcements and giving out general information.

No. 124. By announcement in classes, by publication in Daily Bulletin, by posting on certain bulletin boards, and in some cases by calling in selected individuals for conference.

No. 126. Bulletin boards and notices read in senior classes by department heads. Also items in college paper.

No. 127. By conference with company representatives and through correspondence under the supervision of the personnel officer.

No. 130. Personal interviews by department heads.

No. 131. Handled through personal conferences by the Professor of Mining and Metallurgy.

No. 132. Chiefly through department heads and by bulletin board notices.

No. 133. The professors, chiefly the department head, looks out for employment opportunities and passes the information on directly to such men as he may think qualified.

No. 134. Through visiting representatives of industries. Through heads of departments. Through College Placement Office.

No. 135. By the heads of departments and representatives of industry.

No. 136. Through department heads and industrial representatives visiting the campus.

No. 137. By personal interview by the heads of departments with students and also by announcement to the classes.

No. 138. When in school by a personal interview, otherwise by correspondence.

No. 139. All of our students are on coöperative jobs.

No. 140. Any general inquiry is posted. All civil service examination notices are posted. All may see these notices. Most of the inquiries come in the form of a letter or a telephone call and specific information is given in regard to the type of man desired. In such cases only men who will meet the requirements are informed of the vacancy.

No. 141. By the Dean and heads of departments.

No. 143. Occasionally information concerning very exceptional opportunities come to hand and these are usually conveyed to department heads who, after a conference with the coördinator, approach the young man selected.

No. 145. Through the Dean of men or department heads.

3. Opportunities for Engineering Graduates

Data from 47 Institutions regarding the Graduates of 1929 are as follows:

	Total	Average per Institution
Number of Senior Engineering Students	4282	91
Number ot Industries Visiting Campus	1618	35
Other Contacts	5757	123
Number of Positions Offered	7697	164

4. Initial Salaries of Engineering Graduates—1929 *

Monthly Salary	Area A		Area B	
	Number	Percent	Number	Percent
Below $120	395	17.9	82	13.6
120–124	282	12.8	80	13.3
125–129	451	20.4	155	25.7
130–134	105	4.8	56	9.3
135–139	68	3.1	46	7.6
140–144	148	6.7	18	3.0
145–149	118	5.3	12	2.0
150–154	368	16.7	108	17.9
155–159	53	2.4	9	1.4
160–174	98	4.4	19	3.2
175–199	91	4.1	14	2.3
Above $200	30	1.4	4	0.7
Total	2207	100.0	603	100.0
Number of Institutions	18		17	

Area A—East of the Mississippi and North of the Ohio and Potomac Rivers.
Area B—West of the Mississippi and South of the Ohio and Potomac Rivers.

* Page 234.

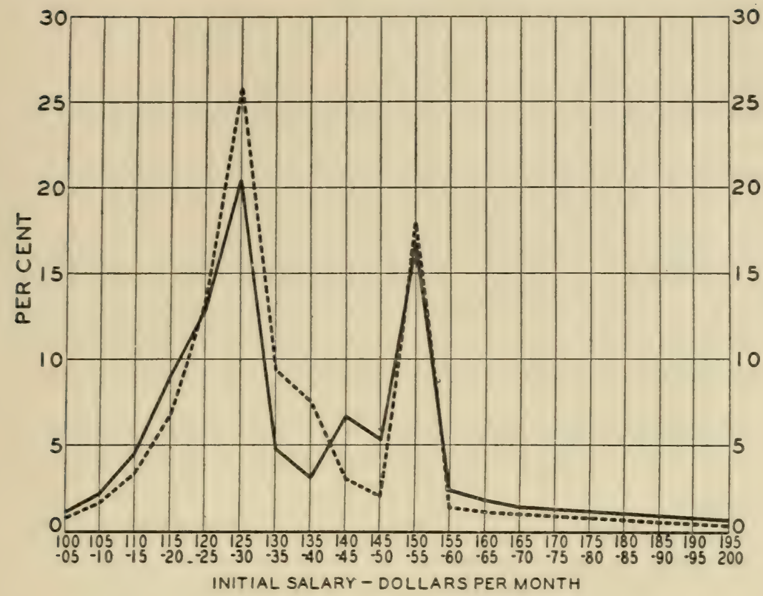


FIG. 5. Initial Salary of Engineering Graduates in 1929

——— Distribution of 2,207 cases in area A
- - - - - - Distribution of 603 cases in area B

QUESTIONNAIRE OF THE 1930 SURVEY

Requesting Data in Connection with Studies of Engineering Education, January, 1930

The following request for information is being sent to institutions which took part in the investigation conducted by the Society through its Board of Investigation and Coördination. The object of this is to secure a measure of the progress which is being made in engineering education in each institution.—Editor.

INFORMATION FOR THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

Institution____

Institutional Representative________________________________

Note:—Blank pages will permit amplification of answers if space provided is insufficient.

PART I

ADMINISTRATION

1. Undergraduate enrollment in Engineering, Dec. 31, 1929.

	E. E.	M. E.	C. E.	CH. E.	E. M.	I. E.			TOTAL
FRESHMEN									
SOPHOMORE									
JUNIOR									
SENIOR									
SPECIAL STUDENTS									
TOTAL									

NOTE: INCLUDE DAY COURSE ENROLLMENTS ONLY.

2. Enrollment of Graduate Students in day courses, Dec. 31, 1929.

	FOR ENGR. DEGREE	FOR M. S.	FOR PH. D.	TOTAL
ENGINEERING				
PHYSICS				
CHEMISTRY				

NOTE: WHERE THE ABOVE FORM IS UNSUITED TABULATE ON SEPARATE SHEET.

3. If evening courses in collegiate engineering subjects are offered give total enrollment, Dec. 31, 1929.
Number receiving credit toward bachelor degree..........
Number receiving credit toward graduate degree..........
Number of students not candidates for degree..........

4. Fees for undergraduate courses. (If different for non-residents of the state, so indicate.)
(a) Tuition for Engineering Courses..........
(b) Tuition for Other Courses..........
(c) Additional charges per year, including laboratory fees, etc., for Engineering Courses..........

5. Cost per Engineering Student per year. (Include only if estimate has been previously made):—
Remarks as to basis of calculation:..........

6. Administrative Officers and Teachers of Engineering Students.

	NUMBER	SALARY		
		MAXIMUM	AVERAGE	MINIMUM
ADMINISTRATIVE OFFICERS (Incl. Dean)				
DEPARTMENT HEADS				
PROFESSORS				
ASSOCIATE PROFESSORS				
ASSISTANT PROFESSORS				
INSTRUCTORS				
ASSISTANTS				
* OTHERS				

* NOTE: PLEASE SPECIFY.

7. Approximate investment in laboratory equipment used for instruction in engineering.
8. General Remarks on Part I..

PART II

STUDENT SELECTION AND EDUCATIONAL GUIDANCE

1. Contacts with Secondary Schools.
   (a) If systematically maintained please state nature of these contacts............
   ....
   (b) Have these contacts resulted in improvements in quality and fitness of matriculants, or in other desirable results?...
2. What is your process of selection of Freshmen?..
3. Admissions.
   (a) Total number of Freshmen admitted this year, up to Dec. 31, 1929
   ....
   (b) Number admitted with conditions..
   (c) Number of Students admitted to advanced standing..............................
      1. From other Engineering Schools..
      2. From other Collegiate Schools..
      3. Transfers from other courses in your institution.................................
   (d) Number of Freshmen who have failed to present required units in the following subjects:

	UNITS REQUIRED	NUMBER FAILING TO PRESENT REQUIRED UNITS
ALGEBRA		
SOLID GEOMETRY		
TRIGONOMETRY		
PHYSICS		
CHEMISTRY		

4. Educational Guidance and Orientation of Freshmen.
   (a) If one or more of the following methods are used please indicate by a check mark.
   ...." Freshmen Week "—Number of days..
   ....Engineering Problems Course.
   ....Required Orientation Lectures.
   ....Series of unrequired talks or lectures.
   ....Faculty advisers.
   (b) Other methods..
5. Eliminations.
   (a) From the original group of Freshmen:—

	CLASS BEGINNING IN FALL OF:		
	1923	1924	1925
NUMBER OF FRESHMEN ADMITTED			
NUMBER REMAINING AFTER 1 YEAR			
NUMBER REMAINING AFTER 2 YEARS			
NUMBER REMAINING AFTER 3 YEARS			
NUMBER GRADUATING IN 4 YEARS			
NUMBER GRADUATING IN 5 YEARS			
NUMBER STILL IN COLLEGE			

(b) Please tabulate below the total enrollment at the beginning of the school years indicated.

FRESHMEN	1923 ———	1924 ———	1925 ———
SOPHOMORES	1924 ———	1925 ———	1926 ———
JUNIORS	1925 ———	1926 ———	1927 ———
SENIORS	1926 ———	1927 ———	1928 ———
NUMBER GRADUATING	1927 ———	1928 ———	1929 ———

6. (a) Do the college records indicate the causes for eliminations..........................

(b) If any analysis of causes for eliminations has been made please state result..

7. General Remarks on Part II..

PART III

COURSES AND CURRICULA

1. Please state the number of semester hours credit required for graduation.

	E. E.	M. E.	C. E.	CH. E.	E. M.	I. E.		
MATHEMATICS								
PHYSICAL SCIENCE								
ENGLISH								
MODERN FOREIGN LANGUAGES								
ECONOMICS								
TECHNOLOGICAL SUBJECTS, MAJOR BRANCH								
OTHER TECHNICAL SUBJECTS								
SHOP								
DRAWING								
ELECTIVES								
PHYSICAL & MILITARY EDUCATION								
TOTAL								

2. What significant changes in educational policy or curricula have taken place in the last five years.

3. What significant changes have taken place in the last five years regarding the number and quality of graduate courses..

4. Where is the administrative control of graduate work placed and how is it supervised?

5. General Remarks on Part III..

PART IV

EDUCATIONAL DEVELOPMENT

1. Have any significant changes been made in teaching methods, and if so give particulars..

2. Have any experiments in teaching methods been conducted? If so, give particulars...................... ....

3. Normal teaching load of Engineering Teachers expressed in total clock hours (class periods of fifty to fifty-five minutes each) per week in actual contact with students in class or laboratory.

Hours per Week

Department Heads . . . .

Professors . . . .

Associate Professors . . . .

Assistant Professors . . . .

Instructors . . . .

Others . . . .

4. Research and Publications.
   (a) Number of Research Fellowships..
   (b) Number of part and full time assistants devoting time to research........
   ....
   (c) Number of published bulletins or monographs on research exclusive of articles in periodicals, except where reprinted. (Within the last five years)..
   (d) Total expenditures for research, 1928–1929 (if available)...........................

5. S.P.E.E. Summer Schools.
   (a) Has your institution defrayed any of the expenses of the representative to these schools?
   (b) What is your impression as to the values received by those who have attended?...

6. General Remarks on Part IV...

PART V

GRADUATE PLACEMENT AND DEMAND

1. Methods employed in placement of seniors.
   (a) If one or more of the following methods are used, please check.
   ....Personnel or Placement Officer.
   ....Dean of Men or similar Administrative Officer.
   ....Department Heads.
   (b) Give brief statement the type of records kept for placements purposes
   ....

2. How is information of employment opportunities conveyed to seniors and undergraduates?

3. Opportunities for Engineering Graduates.
   Please give what information you have under the following:—
   (a) Number of Senior Engineering Students, 1929 ....
   (b) Number of Industries visiting campus, 1929 ....
   (c) Number of contacts through correspondence or other means ....
   (d) Number of positions offered. ....

4. From what information is available, please list below the number of positions accepted at the different initial starting salaries.

MONTHLY RATE	NUMBER OF POSITIONS

5. If any studies of salary progress of graduates have been made in the last five years, list them. Please include the results of the studies.

6. General Remarks on Part V..

FINAL REPORT OF THE CHAIRMAN OF THE BOARD OF INVESTIGATION AND COÖRDINATION *

A BRIEF: SUMMARIZING THE RESULTS OF THE INVESTIGATION OF ENGINEERING EDUCATION AND RELATED ACTIVITIES

CHARLES F. SCOTT †

> "It is therefore proposed that the investigation of the Society be directed to a study of the objects of Engineering Education and of the fitness of the present day curriculum for preparing the student for his profession." (From Memorandum, May 1923.)10 ‡

FOREWORD

The Investigation was initiated in 1922 by the Council of the Society for the Promotion of Engineering Education when it approved the recommendation of a Development Committee that a Board of Investigation and Coördination direct a new project of the Society, "to develop, broaden and enrich Engineering Education." The name of the Board indicated more than mere investigation of facts and conditions; it looked forward to greater unity in the activities of the engineering colleges; it also implied leadership in "Coördination" for concerted effort by the schools to improve the quality of their work and to mesh in with the changing needs of practice.

At its annual convention, June, 1923, the Society pledged active participation; a letter from Dr. Pritchett was read giving assurance of Carnegie Funds which were formally granted in October, and W. E. Wickenden was chosen as Director of Investigations.

The Board of five was augmented by the President and the Secretary of the Society and by two non-engineering educators, President Aydelotte and Dean Seashore. An account of the inception of the project, the organization and procedure, and the fields covered will be found in the Report of the Chairman at the beginning of Volume I, the Preface to Volume II, and at the end of this Foreword. Early records are listed in the Bibliography.

Definite activities began late in 1923. Counsellors were appointed by the professional societies. Professor H. P. Hammond was made Associate Director in charge of relations with engineering colleges.

---

* Presented at the Annual Convention of the Society, June 1934. Revised. Acknowledgment is made of valuable suggestions by members of Board and Staff and by President C. C. Williams who read the proof of this report.

† Professor of Electrical Engineering, Yale University.

‡ References are to pages in bound Volumes I and II of the Report.

Note. For topical outline, see Contents, page lxvii.

Engineering Colleges.—Various studies were undertaken under sponsorship of six committees of the Society. Faculty committees in 150 engineering colleges aided in securing data and transmitting reports to the faculties. Data on personnel, students, graduates and teachers, on curricula, on costs and on other matters accompanied by reports of the committees were the basis of conclusions and recommendations in reports by Staff and Board. Perspective was afforded by European studies of engineering education.[1254]

Publication.—Reports on various projects were continuously published and issued to the Society through its monthly JOURNAL OF ENGINEERING EDUCATION. Reprints in pamphlets and a series of Bulletins together with a Summary of the Fact-Gathering Stages of the Investigation were issued in 1926. Later on a score of these were revised and assembled together with Director Wickenden's ''Comparative Study of Engineering Education in the United States and in Europe,'' in Volume I of the general Report which was issued in 1930; the remainder of the record now appears as Volume II, which contains a comprehensive index.

Summer Schools for Engineering Teachers proposed by the Staff, and supported by the Carnegie Corporation and others were inaugurated in 1927 by three-weeks sessions at Cornell University and the University of Wisconsin. The sessions continued through 1933, and covered the important subjects of the curriculum.[1260]

The 1930 Survey, supplementing the general investigation, which was made by means of a questionnaire issued in coöperation with the United States Office of Education, affords data of the engineering colleges intended primarily for comparison with the conditions five years earlier.[1163]

A Conference of Administrative Officers of Engineering Colleges, held in 1933, dealt with administrative as distinguished from educational problems of engineering colleges. Topics considered were: status of Engineering Colleges in 1933, the outlook, budgeting, development of teachers, students' personnel problems, graduate work, Junior Colleges, engineering education in the light of changed social and economic conditions, external relationships, accrediting of engineering colleges.[1145]

A Study of Technical Institutes (non-collegiate) made in 1928–29 was conducted by Director Wickenden and special staff (R. H. Spahr, principal member) with counsel of an Advisory Committee. It throws light on a related type of education.[1261]

The foregoing outlines the expanding program sponsored by the Board, created in 1922, dissolved in 1934. Supplementing Carnegie Funds there were contributions by Engineering Societies, industries, educational institutions and individuals.

Results and Conclusions are now to be presented. In epitomizing some 1500 pages, including several hundred tables and charts, in less space than required for the tables of contents the stacatto summaries necessarily omit many items and many modifying conditions; these snap-shots may be amplified and brought to clearer focus by referring to the text.

While this report purports to be a Brief, summarizing the results of the investigation, it is frankly somewhat personal in that emphasis is laid on features appealing to the writer as most significant. He has not refrained from advancing his own views and opinions, particularly in the concluding section.

The Beginning of the Project

The beginning of the project was as follows: The Nominating Committee in 1921, while overcoming my reluctance to accept the presidency of the Society, said that new activities were needed and pledged support. My first pastoral letter as President urged local groups to discuss methods of teaching. Something larger was needed but what? and how? The situation seemed intangible.

A leading dean remarked that he disliked investigations by outsiders. I concluded that we should work from within. I consulted President Angell, recently come to Yale. I said I was becoming obsessed with the significance of engineering in modern life; neither the profession and industry nor the schools themselves were satisfied with engineering education as it is, that clearer objectives and new methods were essential and that 150 schools needed coördination and leadership. Was I on the right track? He replied, as I recall, "Yes, engineering education does need something and it can probably best come from within. You will have more difficulty in finding your man than in getting your money, but first of all have you got the schools back of you?" And so I dropped my plan for getting money and asked the Society in the *Bulletin,* January, 1922, whether it would take up its own problems or await outside compulsion. I continued my appeal and at the June convention a development committee was appointed which outlined a comprehensive program under a board of peculiar title. (The Report is printed in the Appendix.)

We soon began our quest for funds. During six months' negotiations with several foundations, we were impressed by the searching and discriminating inquiries which preceded the granting of funds. But we were successful. While we were searching for a director it happened that Mr. Wickenden showed me several charts summing up a comprehensive educational survey of the personnel of the Bell Telephone System. They showed abilities and methods which our director should have. But would he measure up to the whole situation? I did not know him well, so I decided on a test. I asked him to present the results to the Society at its coming convention. Two months later his fascinating presentation of the charts produced a spell-bound interest which one could sense in the darkened room. Several immediately asked why not Wickenden for director? The Board negotiated with him. After several months he consented to leave an outstanding position in industrial education with an expanding future for our adventure into the unknown with definite assurance of one year's financial support and two more if the first showed progress; formal election followed.

At last our plan for development was worked out, the schools pledged active participation, funds were forthcoming, and a director had been found—these preliminaries consumed two years.

These early plans had the benefit of Secretary Bishop's experience and balanced judgment.

From these beginnings, an able Board, a competent staff, earnest workers in the schools, and loyal supporters elsewhere produced the results which are here recorded.

I. PERSONNEL

"A discriminating study of the present state of Engineering Education" naturally began with a study of personnel—students, graduates, teachers. But for the facts one must go to a hundred and fifty independent institutions, with their thousands of teachers, tens of thousands of students and hundreds of thousands of graduates. Often there is diversity rather than conformity to type. Many questions must be answered by individuals as a first step to group averages.

The investigation set about to get the composite pictures of personnel by a fair sampling—securing data from many individuals.

Sources of Data.—Facts and opinions were secured concerning the following individuals in reply to questionnaires. In general, each individual contributed several and in many cases several scores of specific items of information or opinions—

Entering students		4,079
Students (data furnished by institutions)		5,338
Graduates, recent	3,933	
Graduates, older	2,336	
Graduates, Eta Kappa Nu	844	
Former Students	721	7,834
Teachers		2,289
Engineers		1,058
		20,598

The items of information thus secured run into the hundreds of thousands.

The foregoing does not include the totals of certain groups; *e.g.*, the 102,900 entrants which resulted in 41,547 graduates,[201] or the 8,598 teachers who are classified as to degrees held. It does not consider some 16,000 men in industry who are grouped as to educational courses and positions,[1019] nor the graduates of technical institutes, nor does it include the 1930 survey.

Entering Students

Data from 4,000 (20% of the Engineering freshmen in the fall of 1924) show a median age just under 19 years; 96% were American born;[162] Business of fathers—29% industrial, 22% financial and mercantile, 17% farming and 16% professional.[163]

Positions of fathers—43% owner or proprietor, 28% executive and supervisory, 19% workmen, clerks, etc., 4%engineers, 2% teachers.[164]

Education of students' fathers—6% professional degree, 7% college degree, 11% non-graduate of college, 16% high school graduates, 15% non-graduate of high school, 27% graduate of grammar school, 15% less than grammar school.[165] In other words 45% did not enter high school and 76% did not enter college.

The homes of half the students are less than 107 miles from the school; but a considerable number draw half their students from less than 25 miles, 15% migrate from other states.[165]

Of the freshmen 90% had previously earned money; many a substantial amount during the previous year.[166]

Over 60% are from the honor group or the upper third of their classes in the high schools (and less than 3% from the lower third);[166] seven-eighths are from high schools, one-eighth from private preparatory schools or colleges. The quality of preparatory school education, however, is generally inferior as a foundation for an engineering course.[168]

The basis upon which students make their educational choice is wanting in an understanding of what engineering is and the type of man suited to an engineering career. Choice of engineering is made by half of engineering freshmen before entering the last year of high school.[170] While engineering freshmen are of high quality, as high school graduates many are not adapted to engineering careers.[170]

Conclusions of the Committee.—Assistance to high school students in gaining a perspective of engineering as a career, may be rendered by conferences, addresses, literature and moving pictures.[172]

Greater discrimination in admission methods is advised.

Orientation courses in early college years are recommended.[180, 183]

The Report of the Board holds that it is a duty of engineering colleges to the profession to attract and admit qualified students, and to reject the undesirable and unfit.[94]

The foregoing conclusions are re-affirmed and a joint agency for coöperation with secondary schools is recommended.[96] Selective admission procedure and subsequent tests are advised.[96]

Admission of Students

Of 111 institutions 92% have paper requirements of 15 units, the others varying from 14 to 16.[196] Credentials from accredited high schools are accepted by 94%.[197] "Conditioned Students" numbered 20% of the admissions in 1924. Of 65 schools 20% use intelligence tests and 23% personal interviews, though not as part of the admission requirements.[199, 1170]

Comments of the Committee.—Entrance requirements have changed but little in 25 years,[198] and are, in general, about as high "as the traffic will bear." The fundamental problem is to secure better grounding in subjects taught and guidance in selection of electives in the high school.[200]

Should selective methods supplement scholastic credits? [200]

Elimination of Students

Of over 5,300 freshmen in 25 institutions 40% did not survive to enter the sophomore year; similarly 30% of the sophomores and 25% of the juniors were eliminated and 16% of the seniors did not graduate; *i.e.,* only 28% of the freshmen graduated in four years (1923 or 1924).[202, 222] Of those entering in 1899 to 1913 the number graduating four years later is 42%; this includes additions to the class by five-year men and transfers. This changes to 38% for the classes entering in 1914 to 1920. The 1930 survey shows that for three recent classes the corresponding figure is 40%. This survey shows also that 28% of the entering freshmen graduate four years later; this agrees with the findings of the earlier report. Canada, New England and the Middle Atlantic States show elimination ratio much less than the average.[200]

Causes are various. In 23 institutions (1923–24) causes were: Scholastic failure 54%; change of course 15%; financial 9%.[202] Causes assigned by institutions are, lack of ability or of interest 51%, poor preparation 16%; self-support 8%, fraternities and social activities 6%.[204]

Committee Comment.—Elimination (as well as admission) is not merely a matter of "clerical" arithmetic as the problems involved are vital and complex—not routine but personal. Factors in the situation are home training, preparatory education including subjects, objectives and quality as a basis for an engineering education; aptitude and attitude of the student; diverting influences, social and athletic; lack of flexibility and stimulus in initial contacts and instruction; the purpose and character of the engineering school; the relation between the collegiate and the professional aspects of the under-graduate engineering school; the supplying of adequate recruits to the profession; the obligations of tax-supported institutions.

Truly the problem is complex. It has no simple answer, but it must first be stated and understood. One agency in solution is the skill of the teacher in aiding the student to overcome his difficulties and realize his ambitions.[207-214].

Graduates

After admissions and eliminations come graduates. What of their careers? They themselves have supplied data and opinions.

Over 6,000 graduates from over 40 institutions (two thirds of whom graduated within 3 years) are in occupations closely identified with their college courses as follows, Civil Engineers 73.5%; Chemical Engineers 61%; others intermediate. There is more divergence among older graduates.[231]

Of recent graduates 70% are primarily technical in occupation, while 70% of older graduates are primarily administrative.[232]

Median earnings, as ascertained in 1924, increase from $1,500 to $7,500 at the end of 30 years; at that time 25% earn less than $4,300 and 25% more than $15,000.[233]

Initial Positions are secured through college or employer by 45%, through family or alumni connections by 17%; through work prior to graduation by 16%; through personal initiative by 14%.[235]

Reasons for choice of first position: definite field of college course 50%, good opportunities 26%, only one available 10%, desired locality 9%.[216]

One position had been held by 43% of the class of 1922 at the end of two and a half years; two positions by 32% and three or more by 25%.[236]

Opinions of College Courses.—Technical and scientific preparation and the relation of studies to problems and procedures of practice are rated good or excellent by 75% of graduates.[238]

Knowledge of fundamental principles of science and methods of thinking and habits of work are rated as of great or very great value in their college experience by 70%.[239]

Accuracy and thoroughness are developed by engineering courses to a high degree in the estimation of 80%; diligence, also integrity and dependability are similarly rated by 40%; initiative and originality by 37%, and qualities of leadership by 20%.[240]

As important omissions commercial and business subjects are cited by 51%, English by 26%, cultural subjects by 8%.[242]

Continued study is required by the positions of 75% of recent graduates; 51% have studied along the lines of their college courses and 27% along other lines; over 25% studied under supervision of employers; over 40% pursued cultural subjects.

Among cultural interests of graduates, Economics and Literature take leading places, followed by History, Psychology and Philosophy.[245]

Conclusions of Committee.—Two items are given emphasis. The need of guidance in the choice of first positions. Means suggested are lectures to seniors outlining various fields; more effective presentation by representatives of industry; personal records of students by colleges.[250]

Continuation of education after leaving college is essential to the graduate; it should be a responsibility of the colleges. Methods proposed are reading courses, correspondence courses, extension courses of various types, advisory services.[252-255]

The Engineering Graduate in Industry

The National Industrial Conference Board Studies (1924–25) made under direction of a joint committee of industrialists and members of the S. P. E. E., supervised by A. C. Jewett are summarized by him in statistical tables and in comments.[1016]

The studies included six industries. The ratios of the employees in the companies coöperating in this survey to the total in the respective industries are: paper and pulp 32%, rubber 80%, textiles 30%, metal trades 14%, chemical 10%, and electrical 95%. In 1081 establishments over ten percent of the 581,000 employees hold executive or other positions of importance, in the first three industries above named the ratio is 7%, in the others 15%. Of these over one-fifth (13,000) are technically trained college men as follows: textile 10%, metal trades 12%, rubber 14%, paper and pulp 18%, chemical 24%, and electrical 33%. The major college subjects of technical and other college men were; electrical 40%, mechanical 20%, chemical 14%, other engineering 8%, non-engineering 18%.[1018, 1019]

The higher the industrial position the larger the proportion of college men. The proportion in production is low; 70% of the technical graduates are in sales and engineering, the greater number in the latter.

Of 3,800 general officers 30% are technical graduates and 20% are other college men; of 10,800 engineering and technical men the respective numbers are 46.5% and 2%; of 21,000 in production only 7% and 1%; of 15,000 in sales 30% and 8%; of 13,000 in miscellaneous positions 9% and 4%; in a grand total of 64,000, 21% are technical and 4.4% are other college men.

These industries as a whole offer very meager training for graduates, only 31 (less than 3%) reporting organized systems. But as it is the larger companies which provide training the proportion of men receiving training is much greater than 3%.

Lack of specific knowledge (such as the industries might give in educational programs) rather than faulty school training is regarded as impediments to individual progress.

Summer work for college students is recommended by the graduates although few companies extend opportunities.

Graduates in general are satisfied with their technical preparation when their industrial work follows their major subjects; all do further studying.

Very few companies, other than large companies in the electrical and chemical industries, have systematic methods of recruitment. Representatives from a few companies give lectures at the colleges on various aspects of industry.

Conclusions based on statements of graduates and employers are that deficiencies in training are not limited to the engineering college but involve secondary schools (whose graduates are poorly educated and not properly directed) and the educational system as a whole, that the endeavors of leaders in industry and in education should be(*a*) in industry to aid in industrial guidance and in shortening the time for fitting graduates for responsible positions, and (*b*) in the colleges to develop personality, to give facility in expressing ideas in clear convincing English and to aid students in choice of positions adapted to their personality and training. The problem calls for coöperative attack.[1029]

Teaching Staffs

Data were furnished by 2,300 teachers and over 100 institutions.

Sources of Teachers.—From same institution 38% (two fifths directly from graduating class); from other institutions 29% (one fourth from graduating class); from practice 28%. Annual loss; 10% (one third to other educational institutions).[275]

Academic Salaries (median) (1924) are initial, $1,500; in 20 years, $3,500; in 40 years, $4,700. Corresponding supplemental incomes (median) are, $300, $1,000, $1,800.[316, chart] Median academic salaries are slightly less than the earnings of three-quarters of the graduates.[278] The total income of teachers at the 30 year period is 75% of the earnings of graduates (median).[278] Median supplementary incomes are about 50% greater in industrial than in non-industrial centers.[286]

The degrees held by teachers of engineering subjects exceed the number of teachers by 17% (3,693 degrees, 3,159 teachers) while the excess is 50% for teachers of chemistry and chemical engineering, economics and business, and 30% for teachers of sciences, mathematics, English and modern languages.[284]

Professional practice by teachers is permitted in all but 5 of 116 institutions. In these it is encouraged in more than two-thirds and discouraged in very few.[285]

Opportunities for Development are listed with comments under three heads.

(*a*) Sabbatical leave was taken by an average of 15 teachers per year from 116 institutions, and from among a total of some 3,000 teachers.[301]

(*b*) Assistance to younger teachers in securing summer employment is given by 70% of the institutions.[302]

(*c*) Instruction in the art of teaching is given in some or all departments by 10% of the schools and there is no systematic instruction in 85% (5% of 116 institutions did not reply). In a fifth of the schools older teachers visit the classes of younger teachers and in a third young teachers visit classes of experienced teachers. Three-fourths of the faculties indicate that instruction in methods is desirable but express much doubt as to whether a practical method could be found which would make it worthwhile.[289]

Conclusions of Committee. The situation is quite satisfactory insofar as can be judged by the statistics. But intangibles enter the educational problem.[289]

In the selection of teachers, administrative officers feel that recruits are not secured from the highest levels of graduates. Adequate salaries, opportunities for engineering practice and for research and scrutiny of all-round qualifications are remedial measures.[289-304]

The securing of the right type of teachers is a major problem in engineering education.[304, 1151]

II. CURRICULA

Curricula—the *table d'hote* schedules of intellectual food arranged for students are offered in great variety and profusion, although each aims to afford a balanced ration of carbo-hydrates and proteins and vitamines.

Requirements for Graduation vary widely even in the major and fundamental subjects. In civil engineering, the patriarch which should logically be the most stabilized, the total credit hours range from 125 to 191.1 (a ratio of 2:3) in the 83 institutions listed. The total civil engineering subjects have credit hours ranging from 24 to 78 (1:3) while the non-engineering subjects vary from 39.4 to 102 (1:2.6). Comparable or greater variations are found in the other four principal branches of engineering.

Apparently the only common dimension is a length of four years.[454]

Fortunately vigorous youth has powers of selection and assimilation such that physical and intellectual development are not wholly determined by boarding house menus and curricula. Moreover, zest may be added by the skillful cook or teacher.[1068]

These variations in curricula are actually less astounding than they seem in view of the foregoing quoted range from maxima to minima. Curricula in a particular branch, *e.g.,* civil engineering, follow the customary pattern pretty closely in a majority of institutions. They exhibit a range, however, from a broad general education with scientific and engineering background at one extreme to specialized vocational training at the other. This topic is considered later on.

Evolutionary Trends

Evolutionary trends in engineering curricula are traced in 10 typical institutions by comparisons made at 15-year periods from 1870 to 1915 and in 1923. The average for the several institutions shows that in each of the five major branches there is more time than formerly devoted to the major subject and less to foreign languages, shop and drawing. The composite of all courses in all institutions shows also a slight increase in engineering subjects other than those in the major field, in mechanics and hydraulics and in electives. There is a decrease in shop requirements after its peak in 1885. Among the general academic subjects there has been an increase since 1885 in physical sciences, in English and in economics and a slight decrease in mathematics. History decreased after 1885 and has recently held constant, though least in amount among the items listed. The subjects special to engineering occupy (1923) 2.4 and other subjects 1.6 of the 4 years. (These comparisons take no account of changes in entrance requirements or in the total credits for graduation.)[522] In 1870 there were 21 engineering schools, an increase of 15 in the preceding four years. At that time technical education with "its scientific basis and utilitarian aims was regarded as on a far lower plane than classical education."[543] Engineering courses were scientific rather than technical.[545] The evolution has been far more in quality of content than in the quantitative classification of subjects above noted. Changes in curricula have been the resultant of progressive scientific and technical knowledge, and of the changing demands in industrial and other fields employing graduates.

Aim of Curricula

Existing curricula aim to supply a grounding in scientific principles and the methods of engineering together with the elements of liberal culture. They do not afford a complete professional training. They bring material from many fields to a common focus in technical activity. The present trend is placing greater emphasis on general rather than technical educational values. Specialized training follows graduation. Success as an educational process is attested by the many fields in which graduates have been successful.[554, 1070]

Opinions regarding Curricula.—Opinions from 534 experienced teachers in 115 institutions, 6269 graduates and 855 prominent members of engineering societies are presented in statistics and charts and are then epitomized as favoring the following:[413]

1. Moderate diversity, of curricula, but tending away from specialization;
2. Dominance of scientific and broadly technical content;
3. Inclusion of a well-identified core of required subject matter in common;
4. Inclusion at all stages of subjects of purely cultural value;
5. Due emphasis (though not predominant) on the economic aspects of engineering and on its concern with administration and management;
6. Coherence of arrangement and coördination of related subjects;
7. Thoroughness rather than completeness of detail.

III. GRADUATE WORK

Graduate courses were offered in 1924–25 by 81 institutions. Classified enrollments of 746 were reported by 49 institutions and unclassified of 256 by 28 institutions, a total enrollment of 1002. A single institution had 20% of the enrollment, 10 institutions had 87% of the enrollment.[322]

The number of advanced degrees for resident work granted in 1925 by 60 institutions was 572; of these 212 were Master of Science; 194 M.S. with Designation; 25 M.S. in Engineering; 78 included the word Engineer; 63 others included 11 different degrees, 8 of which were the grade of Doctor.[323]

The Committee remarks that nearly all of the degrees are for a single year in residence, that the work is largely of the undergraduate type; that really advanced instruction is given by very few institutions and that very few have faculties competent to train men for high-grade engineering research.[323]

The Board advocates graduate work in a few institutions with notable teachers; that this work be open only to proficient students; that additional undergraduate studies should not be considered as graduate work.[117, 123, 146]

IV. THE COÖPERATIVE PLAN AND OTHER STUDIES

The method of alternating attendance at school and at work in industry initiated by Dean Schneider at the University of Cincinnati in 1906 was adopted by five other schools in a decade and extended by 1925 to include approximately 10% of the engineering colleges, including leading institutions, and 10% of all engineering students of the country. The 16 schools covered by the report include municipal, endowed, sectarian and state supported institutions.[559]

Periods of Alternation between college and industry are of two kinds; either short, 4 weeks or less, or long, sometimes corresponding to the term or semester. A chart indicating the periods for 16 institutions shows that no two are alike.

Coördination between the work in school and that in industry is important and is commonly handled by a "Coördinator," usually an engineering graduate who has himself had coöperative training with supplemented industrial experience. He plans programs and is counsellor to the students.[559]

Earnings of coöperative students (1926) during the work period vary from a minimum of $15 a week during the first year to $50 in the fifth year. These rates vary materially in different parts of the country.[582]

Results of Coöperative Plan. Numerous comparisons between coöperative and other engineering graduates as to positions, earnings and general progress do not show marked differences. It is concluded that both methods produce equally meritorious results though not of identical character. Decision as to relative scholastic merits must await further experience and evidence.

The Coöperative Plan tends to early development of stamina, resourcefulness and sense of responsibility. It also acquaints the student with the importance of the human element in practical affairs. It supplies vocational guidance by the trial method. It facilitates the entrance of the graduate into industry. The coöperative plan affords a close link between the community and the college, a factor of mutual benefit.

Summary. In the broad field of technical training there is room for many types. The coöperative system has established its place and is particularly fitted for the training of men for production in manufacturing industries. Important factors in all education are the interest and enthusiasm of students and instructors—elements to which the success of the coöperative system is largely due when students are carefully selected and effective teachers are found.[613]

Economics

Four-fifths of the engineering colleges have a required course in economics. The subject matter covers the whole field of business administration, finance, and accounting. Total hours in economics range from less than 25 to more than 150. Instruction, except in very few cases, is given outside the engineering departments. The major purpose of the course in two thirds of the colleges is instruction in broad economic theory while an additional 14% combine theory with specific problems. In most cases the teacher holds the rank of assistant professor or higher. Many colleges report that specific economic problems are introduced in their engineering instruction. The importance of economics is generally recognized and many colleges offer electives.[1031]

Replies were received from 127 mature engineers representing the various fields of engineering and occupying a variety of prominent positions. They report a wide range of topics in the general field of economics which they have encountered in their work, viz., valuations, price tendencies, labor problems, cost of public utility services, rates, transportation engineering, legislation, taxation, manufacturing, water power and works, salaries, personnel, business law, city planning, municipal engineering, traffic estimates, finance.

Questions of ''Engineering Economics,'' such as the choice of the more economical method when two are available, the setting of operating charges against fixed costs, cost analysis, public utility problems, financing of industry, marketing and personnel problems, were found to be involved in one phase or another in the experience of practically all the engineers. The large majority advise the inclusion of both theoretical and practical economics in the engineering course. As to whether presentation should be thorough in character or general with emphasis on the importance of the problems involved opinions differed. Those who have had opportunity to observe the handling of economic problems by graduates of business courses and graduates of engineering courses report that the latter are much more competent.

The Committee in conclusion points out that the engineer who does not expect to remain ''a hewer of wood and drawer of water'' but aspires to become a leader in modern industry and business must be qualified to meet economic problems; that the engineering curriculum must confine itself to presentation of the fundamentals excluding topics that are not immediately essential. In what department and by what method and by what type of teachers economics should be presented are vital questions before the engineering colleges.[1038]

The Board stresses two objectives of the social and economic content of the curricula; an understanding of social institutions and the interplay of social forces, also the capacity to deal with specific economic problems arising in the realm of engineering.

The later is essentially technical and is a responsibility of engineering education. Economics is placed in the curriculum on a plane with mathematics and physical sciences.[90, 1058, 1156]

Placement Examinations

Placement Examinations—a series of educational tests designed to measure the training and aptitude of students for subjects commonly included in the first year of engineering curricula—a method employed at the University of Iowa—were introduced experimentally in a number of engineering colleges in the years 1924–25 and 1925–26. Many tests are recorded and from them conclusions are drawn.[689]

Conclusions drawn by the committee are as follows:[725]

A very great range in aptitude and preparation of entering students is demonstrated.

There is a considerable difference between the median scores of students in different institutions.

Placement examinations are valid instruments for predicting scholastic achievement.

They enable classes to be sectioned on the basis of ability, for which the evidence cited is generally favorable; sectioning enables classification on basis of preparation as well as ability.

Placement examinations are ineffective in themselves. They furnish the data upon which remedial measures may be based, however, and when administered systematically and discriminatingly they may be of considerable importance in dealing with students.

Research

Organized engineering research was conducted (1924–25) by 64 engineering colleges in the United States and Canada. An itemized list of particulars shows that there were in progress in June, 1925, 568 projects; that the number of publications issued to that date was 1,658; that the research staff consisted of 927 persons of all grades and that the annual research funds were $1,401,264.

The above figures do not include certain institutions among them Harvard, Yale, Princeton, Columbia and Pennsylvania where research is conducted but not under the type of organization included in the foregoing report. Furthermore the tabular data have various limitations so that the figures given must be regarded simply as indicating general values.

Only 29 institutions report expenditures of $5,000 or more; 75% of the expenditure is by 10 institutions and 90% by 22.

The Committee points out that the "Research" in many institutions is routine testing rather than scientific investigation; that true research is limited to but few institutions; that the total expenditure is only 5% of that for under-graduate instruction; that this amount is exceeded by each of 4 industrial concerns in their research activities; that the importance of research both for its immediate results and for the training of men for research justifies increased development and expenditures.[320]

The Costs of Engineering Education

Data on costs were supplied by 45 institutions of various types having 21,190 students, graduating 3,035 in June, 1925 (the year for which the financial data were given), show the following sources and distribution of funds.[341]

Sources from which funds to meet cost per engineering student per year are obtained (cost including interest on plant $610, excluding interest $487).[355]

Paid by student	$172.00	28.2%
From endowment	124.00	20.4%
Interest on plant	123.00	20.2%
Public appropriation	142.00	23.2%
Other sources	49.00	8.0%
Total	$610.00	100.0%

Distribution of expenditures for engineering education follow:

Instructional salaries	51.5%
Administration salaries	5.3%
Current expenses	18.5%
Equipment	4.2%
University expense charged to engineering	10.2%
Maintenance grounds, buildings	10.3%

In 9 endowed polytechnic institutes the cost per student per year (including interest on investment) ranged in 1924–25 from $384 to $888 with an average of $750. The investment per student ranged from $4,000 to $14,250 with an average of $10,750.[354, 343]

In different types of schools the annual cost per student was as follows: endowed universities $742, endowed polytechnic institutes $750, state universities $474, schools of mines $738, land grant colleges $437.[344]

The cost per student is much greater in engineering education than in liberal arts.[345]

V. CONCLUSIONS AND RECOMMENDATIONS

With the assembled facts and opinions concerning engineering education the Board reaches the following conclusions in addition to those in the preceding sections.

An Undergraduate Course should equip wholesome and qualified youth with a basic acquaintance with science, familiarity with engineering methods, and an appreciation of social relations.[84] These should be coördinated in time and in content and brought to a focus during the last year upon the students major subject.[140]

Three types of activity common to all engineering, for which the undergraduate program should provide a basis, are: [84, 1057]

1. The control and utilization of the forces, materials and energy of nature;
2. The organization of human effort for these purposes; and
3. The estimation of costs and appraisal of values, both economic and social, involved in these activities.

An educational process appropriate to these purposes cannot be narrowly technical.

Engineering Education should be a unified process in which scientific, technological and humanistic studies form an orderly whole; a self contained branch of higher education under unity of supervision.[122] This is in contrast to a divided program having a pre-engineering curriculum under separate administration and a subsequent purely technical curriculum—corresponding to practices in law, medicine and dentistry.[112, 105]

Engineering education is good general education; it is characterized by a coherent and integral program, unifying an otherwise loose group of studies by professional orientation which becomes increasingly significant in the upper years and dominates the post-graduate period.[85, 140]

Four years, as at present, is the recommended norm for an under-graduate course leading to the bachelor degree. Following present high school graduation this implies a median age of 23 at graduation.[85, 138] Students should be at liberty to extend the period to five years to include additional subjects or to overcome handicaps in preparation.[139]

Continuation Education.—College training should be the foundation for the continued development of the graduate either as a professional engineer, or in other fields, by either of two principal methods.[139, 1102]

By resident graduate study preliminary to his future work, technical and professional or administrative or other.

By entrance into practice where experience may be accompanied by continued post scholastic study.

Development from Within

The Board proclaims principles; it does not prescribe rules. Engineering education cannot be static; it has been and must continue to be an evolution.

Engineering education can cope with enlarging responsibility to society and increasing exactions of professional practice by enhancing its own distinctive qualities rather than adding unrelated elements from without. Emphasis on humanistic subjects for enriching the conception of engineering and its place in the social economy, a more connected and better grounding in engineering principles; and greater capacity for self directed work may all be gained at the expense of unrelated studies and detailed training in technique. The latter should find place in post graduate and post scholastic courses.[140, 1048]

For Better Engineering Education we must look to better balanced curricula, better selection of students, better teachers, better methods, better subject matter and better advanced training rather than changes in educational organization.[141, 1045]

Developing Teachers.—For developing teaching personnel each school should have a policy and a definite program covering selection, guidance, engineering experience and teaching methods. Means may include summer schools for engineering teachers, conferences with engineers and with industry.[106] Engineering schools should provide adequate salaries, and encourage participation of teachers in engineering practice.[107] Teaching loads should not prevent personal development and contributions to engineering progress.[108, 1090]

Other Recommendations

The Board states its views on various matters and offers suggestions. Some of these follow.

The credit hours in four years should not exceed 144. Simultaneously carried subjects should not exceed 6.[86]

The Curriculum should be common for all engineering freshmen but for the last year may be widely differentiated; in intermediate years adjusted to local conditions.[86] Options in later years are desirable.

Concrete projects, lectures and conferences should stimulate interest, orient to engineering activities and serve as a try-out of aptitude.[89]

Social and Economic studies should reveal the broad inter-play of social forces and also the specific economic problems and social situations in the realm of engineering.[90, 1048, 1156]

How to place proper emphasis on engineering economy is an open field for experiment by the engineering colleges. General economics should be taught with consideration for the engineering view point.[91]

Specially gifted students should have special programs. Particular programs depend upon sizes of classes and available facilities.[102]

VI. Need for a National System of Technical Education

The engineering college has been reviewed as to its own content and in its relation to preparation of students in earlier years and to the subsequent activities of graduates. What is its place in the American system of technical education? How do our methods compare with those abroad?

We have no national system. Our facilities are concentrated in the engineering college, while provision for other fields is neglected. Technical education is a product of industrial, social and political life and ideals, and in turn is a factor in national development. This is clarified by experience in other countries which indicates that either *laissez faire* or a bureaucratic policy may entail dire national consequences.[142]

France showed remarkable early fertility in technical education and held undisputed leadership up to 1850. Then followed forty years of arrested development; the state held a monopoly of higher education under the bureaucratic system but took no effective initiative; local and private initiative finally took up the burden, but only after the late War did the state resume its responsibility for a balanced and adequate development. Meanwhile the early supremacy had been irretrievably lost with far-reaching effect on French industrial development.

Great Britain, on the contrary, lost fifty years of her early industrial lead over Germany and the United States by leaving all technical education to local and private initiative under an extreme *laissez faire* policy. Britain was equally slow to perceive that a specially selected and trained personnel was needed to apply science to industry effectively. Nearly a century of her effort was concentrated on the incidental education of workingmen, while technical education in the universities was nearly stifled by neglect. It has taken nearly forty years of intensive effort to redress the balance.

Germany.—Technical education in Germany, after being thrown out of the older universities by conservative educators, was taken up and fostered by far-seeing statesmen bent on transforming a group of backward agricultural states into a powerful industrial empire. Nowhere else have technical education and research so largely shaped national destiny. After 1860 it was increasingly clear that while the states and the industries were supplying the motive power of technical education, it was the engineering profession working with educational leaders which was guiding the movement out of its early confusion into a well-ordered scheme.

In the *United States* the pioneer efforts of Gardiner and van Rensselaer, and of their proteges Hale and Eaton, "to promote the application of science to the common purposes of life'' quickly solidified into one special form, that of a professional discipline for engineers. This in turn, was quickly assimilated into the collegiate branch of the educational system which at that time was just taking on an orderly form. Engineering education was already firmly established when the engineering profession became an organized body. In consequence of this early fixation, technical education has had a vigorous development in only one compartment of our educational system. It has developed independently, without guidance by the profession or effective bonds with industry. Its aims have been largely individualistic. The early definiteness of aim has been impaired by the effort to make a single type of school cover the entire range of educational needs. Meanwhile inadequate provision has been made for large sections of our youth in need of technical preparation and industry has been given an unbalanced recruitment.[142, 143]

Our Engineering Colleges are attempting too broad a field, handicapping their true function. A conspicuous need is non-collegiate technical institutes (considered in section IX). Engineering schools require external re-adjustment; they should be relieved of other levels of training.[144] Within their own field engineering schools should not conform to a single pattern, but may develop distinct spheres of work. Students may then select schools and schools may select students. Distinct types of schools may prepare for the higher intellectual and the higher practical functions of industry and of engineering.[146] Some institutions should concentrate on the higher intellectual aspects of engineering both undergraduate and graduate.[146]

A National Agency to consider the whole field of technical education and the external relations of engineering colleges cannot be expected in our government or in industry or in the engineering profession or among educators; it is too big a task for this Society; we must look to some joint representative agency, professional, industrial, educational.[144] That is the solution in America for control which is exercised abroad by public authority and the organized professions as technical education is there considered a part of the national economic system. In America the aim is individualistic—the development of the student. We do not aim to fit men into predetermined molds. National aims and ideals differ. We cannot copy, we must initiate our own national system.[1001]

VII. Our Engineering Schools in Perspective

The ''Comparative Study of Engineering Education in the United States and in Europe''[750] by Director Wickenden contains much information on the development and existing condition in the various fields of technical education in the leading industrial nations. Its significance is in new view points on our own situations. National systems have been considered in the preceding section.[1000]

Quantity Production and Intellectual Standards.—Quantity production of graduates for ordinary needs of industry acts against highly selective schools of high scientific standards. The public rates schools by excellence of plant and size of enrollments. Preparation for the practical direction of industry and preparation for its intellectual leadership are not separated here as they are abroad; as consequences the production side of industry is underrecruited, and on the other hand America has been a large importer of analytical, design and research ability. American engineering is far from being self-sufficient on its higher intellectual levels.[1002]

Preparatory Education abroad has teachers with a standard of intellectual and cultural qualifications quite equal to the average in our higher institutions. Abroad, secondary education is a selective process with great continuity of subject matter preparing for definite intellectual pursuits, but here the aim is not primarily intellectual, rather it is social, aiming to fit young people into spheres of life different from that of their fathers. While we may not reach European levels we ought at least to enable capable young men to reach their present high school graduation levels at 17 or 18 instead of 19 years of age. Improved preparation is an effective way to improve engineering education.[1003]

Curriculum.—The American formal curriculum stands well in comparison, but we have limitations in secondary education and in thoroughness of mastery and coördination of basic sciences. Our sequence of subjects is good, although mechanics often comes too late. We are deficient in the mastery of the few key principles. We lag in the construction side of engineering. This is being remedied in a measure by the courses given by the large electrical industries, pointing a way which others should adopt.[1004]

Specialization.—Our differentiation in curricula along the major professional lines is supported by foreign experience. Although American colleges have a reputation for innumerable curricula and degrees, yet about five sixths of our students are enrolled in the five principal branches. Germany has commendable group options in the upper years of a few major ''faculties.''[1005]

Teaching Processes.—Textbook daily assignment, recitation, written quiz, piece-meal grading; also our pedagogic devices to compensate for defective mastery of the processes of learning; demonstrate the juvenility of our higher education. Deficiencies in preparation, indefiniteness of aims, lack of social and economic urges to achievement, the lack of intellectual traditions in society and of standards of scientific competency in the technical professions have compelled our engineering colleges to resort to a driving process. The American student has less freedom and more routine; he is not an independent spirit striving for a distant goal; he is a harried quantity producer with recurring daily and weekly tasks. We may accomplish more with the average student, but we sacrifice the superior student of originality and imagination. The root of the problem is in the teacher, often overloaded and ill prepared to teach his subjects and with little conception of better ways. In general, we have not studied how to handle large groups, our students expect to be taught, our leadership is quantitative. Electrical students at Stockholm, Delft, Berlin and Zurich were observed to have less equipment but presented laboratory reports showing critical analysis and little of manipulation, observation, descriptive writing and compiling.[1006]

Training in Management.—It has been easier to introduce the economic sciences into our technical education than in the compartmental systems abroad. France has been successful due to rigorous selection, high intellectual formation, professional teaching by eminent practitioners, industrial *stages,* officers training with the army and the confidences and solidarity bred of being a *Polytechnicien.* American curricula in industrial engineering and management are attracting attention abroad. Qualified teachers with responsible experience are hard to find abroad as well as here. The revamped economist, psychologist or statistician is no nearer the engineering ideal there than here. Management is still far from a mature and orderly science. Higher education for business is not going any too well abroad and is not the rival of technical education as it is in the United States. German technical universities conduct research on selection for industrial vocations and on laws of efficiency of human work. Research first, teaching afterwards.[1007]

In Technical Research (1927) our institutions are in advance of France, behind Central Europe and only on a par with Great Britain although our university organization is on a vastly greater scale. Until recently our colleges have regarded research as merely an incident. Few men of high research ability are in the schools; they are in industrial research. Research personnel cannot be improvised; that of Germany is the product of a century of cultivation and selection. We have had a scattered policy, bringing a large area under cultivation rather than the intensive cultivation of a few plots. A strong spirit of inquiry and creative effort in our colleges is more important than juggling with curricula. Good students educate themselves if environment permits. Pure scientific research is an indispensable adjunct but not a substitute for technical research.[1008]

Status of Engineering Teachers.—The prestige of the engineering professor is higher in each of the ten European countries visited than in the United States. In comparison it appears that many of our engineering teachers are industriously attempting a task for which they are inadequately prepared, either by scientific training, professional experience or broad personal culture, and that the technical professions and industries of America do not keep teachers of highest fertility at the source of their recruitment. Germany practices what we do not yet clearly envisage. The present rise of scientific standards was not anticipated in the training of many teachers now in middle life who will remain in front line positions for many years to come. We should concentrate on a dozen best equipped institutions in raising the levels of graduate work; send selected men abroad; send men from industry to graduate schools, and keep our most promising men free from deadly routine.

Although American teachers may lack in scientific attainment they excel in devotion to the improvement of their processes and the individual welfare of their students.[1010]

Student Life.—The multifarious activities of student life give worthwhile opportunity for self-discovery and personal experiment which are often the basis of future careers. The problem is one of proportion. Normal participation in general activities should not be strangled by an academic load of routine. English sport is far more wholesome than our high-powered competitive athletics. Self-support may divert too much of the student's energy. It is not in favor abroad. We should consider deferred payments or coöperative methods rather than to depend too much on casual earning power.

Integration of Academic and Practical Training.—In theory our technical profession upholds that practical training is indispensable to the engineer; in practice it is left to the individual to do the best he can. Only a few concerns in the electrical and chemical industries train broadly. Other employers usually train for their specific needs rather than as part of a broad professional development.

British and Germans insist that practical training shall have form and substance.

Where the coöperative plan is impracticable other means should be found for systematic practical training. The schools, professional bodies and industries should come to clear agreement on aims sought and specifications to be met. Until the colleges know what training employers will furnish they cannot intelligently adjust their own courses.[1012]

The More Intensive Form of Higher Education.—Our concentrated effort on degree-granting colleges is in sharp contrast to European methods which provide a comprehensive system directly adapted to the needs of industry. They give intensive training to the less book-minded who lend themselves better to more direct practical and inductive methods of learning. This subject is elaborated in Section IX, Technical Institutes.

Conclusion.—We are training American youth for American life. Our teachers must guide as well as instruct. Our students must experiment with life as well as with mechanism. Our colleges must supply incentives from within which abroad are supplied by economic pressure from without. Part of our technical education must be lifted to higher scientific levels.

The crux of our problem is to unite a higher concern for individual development with both a higher intellectual standard and a higher practical standard of technical preparation. These ends are achieved abroad through selective processes which reach to the very foundation of the social structure. No single type of school nor compromise type of program will solve our problem. We need more clearly visualized aims and programs to develop a willingness to accept different but equally worthy functions in the social order. The situation is a joint responsibility of educators, the technical professions and industry. It is a test of American capacity for self-government through group coöperation.[1014]

VIII. Summer Schools for Engineering Teachers

Of all the many ways in which it was found that engineering education might be made better, the outstanding one was better teachers. Whatever might be done in the future to select and develop teachers there was the immediate present problem, How can the quality of present teachers be improved? In a previous section it is recorded that many faculties considered training in the methods of teaching as desirable, but questioned its practicability. Happily a plan of teacher development was evolved and put into effect on a scale large enough to produce useful results and also to indicate the desirability of continuance.[1117]

The Summer School project brought together teachers in a particular subject for a three-weeks' session in which they might qualify as better teachers. Programs of the sessions included lectures, model teaching exercises, laboratory and lecture room demonstrations, seminars, and work carried out by committees of members of the groups. Methods of teaching were stressed in all parts of the programs; subject matter being considered chiefly in its relation to method. At each session advanced phases of the subject under consideration were presented with the purpose of stimulating interest and promoting further study.

In all there were 12 sessions, two during the first summer devoted to mechanics and others later covering subjects of electrical engineering, mechanical engineering, civil engineering, chemical engineering, mining and metallurgical engineering, engineering drawing, physics, mathematics, economics and English. The total enrollment was 721, an average of 60 per session. The members of the staff totaled 376, an average of 32 per session. The average number of institutions represented at each session was 41. Many of the presentations by staff members were written papers. Selections from these of more general interest were published in the Society publications or in those of the Civil and Mechanical Societies and reprinted in bulletin form. Assembled these would make volumes of some 1,700 pages, the cream of the presentation of experts in many fields. The papers deal with the historical, technical and pedagogic phases of the various divisions of engineering teaching.

Some of the groups have maintained a continuing organization, holding conferences in connection with annual conventions of the Society.

The Summer School was the prototype of the notable conferences in connection with the annual convention in 1934. A score of groups primarily of younger men held conferences on many phases of engineering education on the two and a half days preceding the opening of the convention. About as many participated in these intensive and animated presentations and discussions as were enrolled in all the sessions of the Summer School.

The Editor of the American Society of Mechanical Engineers, a former teacher and a member of the Council of The Society for the Promotion of Engineering Education, attended the Summer School for Mechanical Engineering. He reports (condensed):

> To evaluate the results one must give substance to many intangibles. A golden opportunity for the young instructor, subjects were presented in a new light, old problems were given new significance, and inspired enthusiasm, sectionalism was dissipated; teaching problems are fundamentally the same. Fortunate the college whose faculty has the more mature outlook the Summer School affords; notwithstanding this more than half of those attending received no expense funds from their schools.
>
> Engineering societies have a stake—their future is determined by the quality of graduates the schools produce; hence they are concerned with the sort of teachers who train engineers. For three weeks deans, professors and instructors lived together, ate together, sat together in class rooms, 90 of them came from 60 institutions in 36 states and two Canadian Provinces.
>
> The staff selected from colleges and industries contributed a rich program. The program at times simultaneously dealt with heat power, machine design and production; these were handled by experts interested in the teaching of these subjects.

Some impressions: A reassuring conviction that teachers of engineering are on the right track. In an age of sudden changes and new environment methods of education change; engineering teachers have preserved a conservative balance with progressive vision. They are unique in boldly questioning their aims, ideals and methods with the hope of improving themselves, their schools and their product. They have been unique among teachers in the thoroughness of their studies and in definite formulation of their essential ideas. Colleges of liberal arts with varied programs have not worked out definite plans as their objectives lack the definiteness which gives form to the engineering curriculum and the educational needs of the graduate engineer.

IX. A Study of Technical Institutes (1928–29)

Principal Findings and Conclusions *

Occasion for the Study.—Our several branches of technical education have grown up independently. The field has been open to free enterprise, and it has been nobody's business to explore the whole situation and plan comprehensively. Certain dominant types have emerged, but we have created nothing which resembles the carefully conceived and articulated national systems of technical education which exists in Europe. We have had the benefit of much unhampered pioneering, but have permitted broad gaps to develop.

This study deals with one of these gaps. The engineering college is one of our strongly defined types of institutions, and trade and craft schools are acquiring a more typical character and standing. The type of institutions known in Great Britain as the ''local technical institution,'' and the ''technical middle school'' of Central Europe have only a few and scattered counterparts in America.

Characteristics of the Technical Institute.—A school of post-secondary type, but distinct in character from a college, to train for callings and functions between the skilled crafts and the highly scientific professions. Many graduates advance to a professional status, principally those who found their bearings early and sought intensive preparation for chosen lines. Training is both for technical pursuits, planning and control, and for supervisory positions, operation and maintenance. The engineering college emphasizes the former, the technical institute the latter group. Intensive in purpose, courses are shorter than those of the colleges. Without academic standardization admission and graduation requirements are less formal and stress capacity and experience more than credit units. Teaching is relatively direct with emphasis on doing, as

* The Full Report is in Volume II, Part 2.

distinct from book study. Teachers, while possessing adequate scholarly preparation, are chosen primarily on the basis of practical experience, personal sagacity, and ability to teach through programs of orderly experience. Instruction follows the actual usage of industry.

Summary of Principal Findings and Conclusions.—With the rapid shift toward higher standardization and automatic processes, the total labor requirements in American industry tend to diminish, but there is a striking rise in the proportion of staff experts and of highly trained technicians and supervisors. Industry must therefore look increasingly to technical schools rather than to its rank and file for its technical and supervisory personnel.

The situation in industry warrants a great expansion of technical education above the present level of the secondary schools. There should be a greater diversity of technical education to serve a wider variety of individual and industrial needs. To maintain but one type of school (the engineering college), and to ask it to meet all purposes is to invite blurring of aims and compromise of standards. The need is for schools having more definite purposes and more clearly visualized aims.

Engineering colleges, graduating about 9,000 men each year, leave many of the needs of industry unprovided for. Engineer and sales staffs are fairly well recruited; production, operating and maintenance staffs most inadequately. Manufacturing industries estimate their normal requirements of four-year engineering graduates at from 2.2 to 3.0 per cent of their total forces. This potential demand is perhaps one third supplied. The same industries estimate the desirable quota of employees having approximately two years of training above the secondary level at from 6.0 to 8.3 per cent of their total forces. At present this potential demand is not more than one fiftieth supplied and an output of from 25,000 to 30,000 graduates a year from technical institutes could be absorbed to great advantage.

Graduates of technical institutes have shown adaptability to the requirements of industry in the following order: supervision in operating departments; plant operation and maintenance; getting on with workmen; technical services (drafting, designing, testing, inspection, etc.); team work with associates; coöperation with executives; construction and erection in the field; accepting plant hours and conditions; technical sales work. The largest groups are supervisors, engineering personnel and proprietors of business. These graduates are somewhat more stable in their early employment than engineering college graduates. The median earnings of the two groups, for equal age and experience show only a moderate margin in favor of the college men. Wherever the product of the technical institutes is known, the demand greatly exceeds the supply.

The technical institutes cater effectively to young men who have industrial experience and orientation, to men who have a career definitely planned, to men who have passed out of a state of book-mindedness, to men whose natural learning processes center in actual doing rather than formal study and to men who for financial or other reasons cannot devote four years to preparation.

Enrollments in day technical schools, both full-time and part-time, can be greatly increased. The urge toward technical pursuits normally asserts itself between the ages of 16 and 19. Technical education needs to be made widely available locally, a technical institute might thrive in most cities of 50,000 or more.

Technical institutes should have their own distinctive field and character. Attempts to give the more intensive and practical forms of post-secondary technical education in auxiliary departments of standard engineering colleges have largely failed, through becoming salvage courses for failures in the longer courses. Wherever its distinctive aims are not clearly visualized and tenaciously pursued, the technical institute tends to drift into the college field, often to the neglect of the very groups it was created to serve. The mixed type of technical institution has succeeded well only in Great Britain, where a powerful tradition and the strong hand of the central authorities unite to keep the non-degree courses in a dominant position.

There is no basis in experience for expecting the junior college of a mixed character to do the work of a technical institute successfully. The technical institute needs a director and staff who are in intimate touch with industry and especially proficient in blending scientific and practical instruction rather than leadership of the ''educationist'' type.

The day technical institute with an evening department is the objective. It is difficult to maintain an efficient staff for evening work, unless the school is an auxiliary to a day school or to a large industrial establishment.

The coöperative plan, based on alternating periods of school work and industrial employment, seems particularly well adapted to the aims and the levels of age and work of the technical institutes. The coöperative plan does not obviate in any large degree the need for extensive scientific and technical equipment; in fact the demands on equipment in a technical institute are fully as intensive, if somewhat less varied, as in the engineering college.

Much of the success of the European institutes is due to their close adaptation to regionally specialized industries. Monotechnic schools in such fields as textile manufacturing and bituminous coal mining are especially dependent on environment for success.

The actual needs and the potential demands are beyond the resources of voluntary and private agencies, although the latter have important contributions to make to the enterprise as a whole. The needs of the country could scarcely be met by less than 250 institutes, and seem to call for the creation of a great chain of community institutions having an organic place in city and state educational systems, yet free to achieve their own distinctive character.

The independent, endowed technical institute resembles the endowed college or university. In American experience private initiative has been quicker to recognize neglected areas of education and to occupy them than public authorities. After successful efforts have gained some prominence, the public steps in and meets the larger needs. The independent schools are then able to capitalize their freedom for experimentation with curricula, teaching methods and selective standards of admission. Welfare organizations have entered this field with the aim of serving men not provided for by other agencies at the level of their actual needs. As a rule these organizations have been under the necessity of making their educational activities pay their way in full. The temptation to "window dressing" has been strong and the limited resources, personnel and equipment have left room for doubt as to the quality and permanence of their work, if once the public awakens to its responsibility.

Cities of less than 50,000 population, would find it impracticable in most cases to maintain municipal technical institutes. If this gap is to be filled it must be done largely by the states.

The largest field to be served by the technical institutes appears to be that of training men in the technology of particular industries rather than that of generalized engineering courses of broad aims. Schools for specific industries are greatly needed and no question of depressing professional standards can possibly be raised. Schools for the textile industry, the foundry, machine production, instrument makers, building construction, printing and engraving, horology, coal mining, and the leather industries are types widely established abroad and in great need for multiplication in America. These industries could use great numbers who have had two years or more of training adapted to their specific needs.

A lack of solidarity among the existing technical institutes has held back the development of similar schools over the country at large. Each institution has grown up around some local situation or some individual's vision, but with little sense of aims in common with other schools. Their heads have wisely sought to preserve this individuality. The result has been an emphasis on points of dissimilarity, amounting to a spirit of mutual aloofness. Thus separated, they have been unable to create a recognized status of their own. They were too often known as non-this or non-that to impress themselves on the consciousness of the country, much less its imagination. Their faculties suffer from a sense of professional isolation. There was no forum for their common problems and no organization for a united initiative.

Technical institutes have been handicapped by the fact that their graduates received no educational credentials which are nationally recognized. The temptation has been strong to become colleges and award degrees. British educational authorities and professional societies have met a similar problem most effectually through the establishment of National Certificates, National Diplomas, and Certificates in Technology awarded by central bodies.

Training in the Tcchnology of Specific Industries.—Courses in the technology of specific industries involve a higher order of specialization than an engineering course, yet not necessarily a narrow training. Printing, iron-founding, coal-mining, photo-engraving, tanning, papermaking, cotton-spinning, watch-making, die-casting, framed construction have each an underpinning of scientific knowledge and a content of rational practices. Each draws selectively on many sciences. One need not know all of chemistry to be an expert in paper making or all of physics to master the art of cotton spinning or weaving.

Training for Specific Technical Functions.—This type represents a high order of specialization. An example is the work of the quantity surveyor, who takes off from building plans complete schedules of the quantities of materials, areas, volumes, numbers of unit items, etc., from which bidders may estimate their costs. One must have intimate knowledge not only of plans and conventions, but also of specific details of construction not represented on the plans. On the other hand, a limited knowledge of design calculations for strength and resistance, and the like, will suffice. In educational courses of this type it is entirely practicable to proceed from a detailed job analysis and one may safely trim the program to strict essentials. Most of these specific functional jobs have outlets to posts of responsibility. This field of education belongs by rights to the technical institute.

Much of the demand on the engineering colleges could be filled by technical institute graduates. Thus relieved, the colleges could emphasize more truly professional aims and standards. From the viewpoint of industry, a thoroughly trained technician or operating supervisor ought to be more acceptable than a half-baked or ill-adjusted engineer.

Data re Technical Institutes

Requirements of Industry.—Fifty-eight manufacturing companies in New Jersey report their needs for technical men from technical institutes and from engineering colleges as follows:

Branch of Engineering	Technical Institutes	Engineering Colleges
Mechanical	817	316
Electrical	116	111
Civil Engineering	6	18
Chemical	345	146
Mining	6	4
Miscellaneous	12	0
Total	1,302	595
Ratio	2.2	1

Another group of 21 New Jersey industries reported a ratio of 2.7 : 1.

Public Utilities of New Jersey (not including communication) reported a ratio of 2.7 : 1.

Employment managers of 12 large companies in California in a classification of 75 types of technical positions found a ratio of 2.6 : 1.

These closely agreeing results from four independent sources are impressive.

Estimated Positions Available for graduates of technical institutes (1928) is 40,000 to 50,000 annually. This is based on census reports of the number employed and upon the ratio recommended for technical institute graduates to total employees by companies using such graduates.

Aims Suggested for technical institutes by 15 concerns who used graduates were in order of importance for qualifying men (*a*) for supervisory positions in operating departments, (*b*) for technical service, *e.g.,* drafting, designing, testing, (*c*) for commercial positions relating to sale of technical products.

Records of Graduates. A high percentage of graduates report general satisfaction with their courses as a preparation for their careers. Over 80% indicated need or desire for additional study although less than half of these had enrolled in additional courses.

The lack of a degree was a handicap to only about a quarter of the graduates in securing employment or in securing advancement, or in recognition by professional or business organizations.

Five sixths of the graduates were employed in fields the same or closely allied to their school courses.

Outstanding traits were adaptability to supervisory, operating and technical services, ability to get on with workmen and to do team work and to coöperate with executives.

Earning power of a group of 1,000 two-year technical institute graduates is within about 5% of the earnings of a large group of four-year college graduates. The earnings of 200 one-year graduates is 15% to 20% lower for the first 10 years after graduation and then advances very slowly.

Students.—The fathers of students are proprietors and employees in business and industry, 70%; farmers, 12%; professional and brain workers, 18%.

High school graduates range from approximately 50% to 90% in 13 institutions.

The median age of students in eight-day institutes ranges from 20 to nearly 22 years. In five evening institutes from 20 to 24 years. More than half of the day institutes have students over 30 years of age and all but one of the five evening institutes have students over 35 years of age.

The day institutes have students with prior full time industrial employment over 75% and evening schools over 85%. Nearly half of the students earn three quarters or more of their expenses, some prior to entrance, some during vacations or during school time.

Qualifications of Teachers.—In 10 representative institutions 70% of the teachers hold college degrees. Of 239 reporting 39 hold the master's degree and 45 professional degrees in engineering. A very large proportion of the teachers have a number of years experience both in industry and in teaching. Nearly a third of the teachers are below 30 years of age and about a third are over 40.

European Institutions.—In European countries the technical institutes are government schools. In France there are national schools of industrial arts; in Great Britain there are under joint support local and governmental more than 200 technical institutions; in Germany the higher industrial schools are under state and municipal auspices; in Switzerland the *technicums* are maintained by the cantons. The established character and the recognition of these schools as a part of the national economic system is in marked contrast to their position in America.

X. Summary of the Results—the Intangibles

The findings of the investigation and the conclusions appear in the preceding sections of this summary. The initial purpose to study the objects of engineering education and the suitability of existing curricula resulted in a notable collection of facts and opinions regarding the many phases of engineering education.

Resume. It was found that the objectives and practices of our engineering schools called for no revolutionary treatment and that improvement can best come from readjustments, and extensions and from betterments of quality.[1090]

Our American youth can best be served by an engineering college which offers a balanced ration of the scientific, the technological and the humanistic. This is a type of general education of scientific background preparing for many activities in modern life. It should be so shaped as to prepare for entrance to the engineering profession, either through graduate study or a combination of practice and post scholastic study, as preliminary to either the more technical or the more administrative field.[1056]

Betterments are proposed, particularly in the quality of entering students and of teachers and in facilities for college work by the highest type of students.

Technical education is surveyed on a national basis and it is found that the engineering college is attempting to cover too large a field; part of what it is attempting could be much better done by a different type of school with briefer and more intensive training—The Technical Institute. A study of engineering education abroad, which was included in the original program of the Investigation throws much light on our American methods.

The Summer Schools for engineering teachers demonstrated on a large scale the potency of extending opportunities to faculty members for self-development as teachers. This practical plan for the betterment of engineering education was based on the findings of the Board that what is most needed is better teachers.

It remains to point out other influences and results, often intangible as they cannot be measured quantitatively; their significance must be a matter of opinion; others may assign different values than those here implied.

Engineering Education as a Whole.—One's idea of engineering education is often based on personal experience as a student in a particular institution years ago. Even teachers sometimes are familiar with only one or two institutions. These reports present a comprehensive view—Engineering schools grown in 70 years from a half dozen to a dozen dozen contributing the men who did their bit in changing the ways of life and in building a Century of Progress.

Teachers in these individual schools of various types, intent on improving the quality of their work have voluntarily allied themselves in a Society which has become the National exponent of Engineering Education.

What is the typical school and teacher, student and graduate, just how does the educational machine function, what is it accomplishing? The Society has sought and found the answers.

In the report are tables and charts, descriptions and summaries treating engineering education in the large, telling the story by facts gathered from un-numbered sources.

The Complexity of Engineering Education.—One is apt to think of engineering education as something simple and definite, but the successive sections of this Report reveal its inherent complexities and its external relations, all brought to focus on the few years in which the high school graduate prepares for his life work. The freshman himself—heredity, environment, education and ambitions; the curriculum—a resultant of traditions and local environment, a meeting ground for the humanistic, the scientific and the technological departments of instruction, the resultant of conflicting objectives and ideals which forms the actual program of contact between students and instructors; instructors—their ability, knowledge, personality, attitude, and skill as leaders; college life with its opportunities and temptations; the after-graduation period with its continuation of development and its hit-or-miss introduction into practical life; the contribution of the graduate to professional life, to industry, to public affairs and citizenship; the significance of scientific and technically trained men in industrial and social affairs and on the national economic system as revealed in the studies of different countries—all these are typical elements which are brought to focus in engineering education.

Our Technical Education is Unbalanced.—To the writer the outstanding surprise of the investigation was the fact that industry needs only one college man to nearly three men trained in another way—in a type of school which did not have even an accepted name, for which we coined the term Technical Institutes. Obsession for degrees and concentration on collegiate forms of education have unbalanced our system of technical education. The engineering colleges have been attempting work outside their own sphere. They can do much by internal improvements, but they need also new environment, better preparation of entering students, better continuation training for their graduates, more schools of different type in parallel to relieve the colleges of a misfit burden and to do well what the colleges are now doing poorly.

A recruiting agent recently asked ''Who are your best men? In the past we have taken many and the merely good men have fitted into routine jobs, but we find the firsts from high schools and night schools go up faster than the seconds from the colleges.''

Industry is now practicing the selective admission which is advocated for the colleges.[1077]

Stimulation of Interest in Education and Teaching.—An initial principle and a final conclusion is that betterment should come from within. The method of the Investigation has promoted that development. The Society accepted the challenge to analyze and solve its own problems. There was formal participation by seven or eight hundred faculty members in committees which collected data of their own students, teachers and graduates. Knowledge of their own conditions and problems prepared them for interest in assembled data affording comparisons. The enormous amount of arduous work done voluntarily in the assembling of data and the preparation of reports by faculty members is strong testimony to the interest of college teachers in their work.[1042]

Appreciation that there is a problem and its formulation are first steps to its solution. A leading dean remarked that never before had his faculty really become animated in discussing their educational problems. An outside observer whose contact with schools gives a valid basis for his opinion says the outstanding result of the Investigation is improvement in teaching, brought about through direct training and the comparisons, direct and indirect, which have spurred on to new methods.

A Basis on which to Build.—Engineering teachers and administrators have remarked that these reports give a basis of fact on which to plan. What they only thought was so, now they know is so.

Papers presented to the Society proposing educational advances take the recommendations of the Board as their starting point. Our reports are used as guides in plans for industrial educational projects. The reports have supplied arguments for strengthening curricula.

A New Solidarity. Working together creates comradeship. Near-sighted deans, teachers in ruts, isolated institutions have new perspective, new fellow feeling and understanding. The Society is not an organization devoted to the publication of idealistic papers but it is a coöperative institution. This has been fostered by effort in a common cause and by reports and data which have made institutions which were strangers familiar with one another. Our hundred and more institutions with their thousands of faculty members have been given a new union and new solidarity. This has been made concrete by the practical tangible character of the Investigation.

There is a new unity between related departments. The Summer Schools for Teachers of Physics and Mathematics and English and Economics have led to mutual understanding and purpose. The departments have not been treated with aloofness but as important contributors to engineering education, they have new understanding of engineering ideals and purposes.

All this is in realization of the ideal which is incorporated in the title of the Board, "Coördination."

The Engineering Societies.—The Board has sought to bring the engineering societies in closer relationship to the schools. Its headquarters were located in the Engineering Societies Building. The societies have long maintained student branches. At the beginning of the investigation they appointed counselors and later contributed opinions by leading members, they contributed funds for the Summer School and participated in them. They have developed an increasing interest in education. They have recently joined with our Educational Society in the Engineers Council for Professional Development, looking to a comprehensive scheme for the development of the professional engineer. Incidently it may be mentioned that the program of the Council follows closely a schedule presented by Director Wickenden in a paper entitled, ''What the National Societies Can Do for Engineering Education,'' presented before the American Society of Mechanical Engineers in 1927 and that a considerable number of the Council are former members of the Board and Staff.

These relationships may develop into that representative agency for engineering education which the Board has advocated. All this is further realization of ''Coördination'' which has been a dominating ideal.

Orientation of Engineering.—The survey clarifies many relations within the individual schools and many inter-relations between schools; also between the educational institutions and industry, and the professional societies. A better appreciation of these relations tends to a unity by welding together the elements which enter into engineering. Contemplation of the whole gives new dignity to the profession looked upon from within or without. It gives a sense of sweep and unity in engineering education as an ascendant, possibly a dominant influence in our twentieth century civilization.

The Project in Perspective.—The Board followed no precedent; it had a purpose but no pre-determined program. Plans were formed to meet conditions as they were discovered and to realize objectives as they proved valid.[5-12, 1041]

A perspective view was ventured by Professor Hammond in concluding a recent letter:

> ''The project of the Society, under the Board's direction—the two Investigations, the Summer Schools, the Administrative Conference, and all of the attendant activities—has constituted one of the major programs of study, investigation and movements for betterment in the entire field of higher education. I doubt whether any other more comprehensive, or more fruitful, endeavor has ever been undertaken and carried through in any division of education, not even excepting medicine. We have been so close to the woods that we are inclined to speak only of the trees, meaning number of publications, number of pages, details of all sorts, and we forget with what a large undertaking we have been concerned.''

Any general appraisal of this undertaking as an educational endeavor must recognize as outstanding features its mode of procedure, the broad fields from which facts were gathered, the wide sampling of opinion and the solidity of the results attained. Its tenets, compiled in the midst of industrial prosperity and expansion, still seem to stand well-founded after an economic cataclysm and a half-decade of depression.

Finale

And now comes to a close the formal existence of the Board and another chapter in the development of the Society for the Promotion of Engineering Education. Formed in 1893 to promote engineering education, it has been a pioneer in self-development. During more than half of its two score years it has conducted investigative projects. In 1907 it initiated a formal study of its field and its problems, in which external agencies predominated; then in 1923 it undertook a coöperative self-investigation which developed an expanding program whose results are here recorded. Thus is carried forward the ideal on which the Society is based.

The Board has proposed no leap into Eutopia. Engineering fashion it has first found the facts. If we know where we are and the way we have come we can better determine where to go from here.

This ''Final Report'' does not mean finality, but like a diploma it signifies for the Society a Commencement time of a larger life.

Of the results of the investigation, tangible and intangible, possibly the most potent may prove to be the inspiration and stimulation of younger teachers to careers which in future will ''develop, broaden and enrich Engineering Education.''

APPENDIX

REPORT OF DEVELOPMENT COMMITTEE *

Letter of Transmittal

PITTSBURGH, PA., August 8, 1922.

TO THE MEMBERS OF THE COUNCIL, S. P. E. E.

Gentlemen:

At the Urbana convention you provided that the President should appoint a committee of five, including himself, to study the development of the Society.

I appointed President F. W. McNair, Dean M. E. Cooley, Professor D. C. Jackson, and Professor J. H. Dunlap, recently elected Secretary of the A. S. C. E. As provided by you, the Secretary of the Society, Dean Bishop, has acted with the Committee.

The Committee met in New York on July 10, 11 and 12 and then practically completed its report in Pittsburgh on July 19. It was afterward edited and revised in form. Professors Jackson and Dunlap were unable to attend these meetings.

The Committee has proposed for your consideration a program and a plan of action. It has not been unmindful of various matters to which reference has not been made in the report such as Sections and Branches, enlarging and enriching the Bulletin, and the employment service, but these are regarded as secondary and furthermore they would presumably follow the activities proposed.

Our real function as a Society is to develop teachers who can train engineers. Real progress must come largely from inward growth. The greatest gain must come from better teachers and stronger faculties. The present plan is not something apart from the schools; it is not a scheme by which some super-committee shall evolve a solution to engineering education in a formal report. The movement contemplates active participation by the schools and the proposed organized effort should have its richest results in directing attention, awakening interest and securing participation of engineering teachers and faculties in this work.

A statement of why you are endorsing, if you do, this project will be serviceable in securing funds and in maturing and working out a detailed plan. Talk it over with others. Create and crystallize sentiment.

In response to requests letters of suggestion have been received from a number of members. These have been constructive and of material assistance Practically all have suggested a general plan of investigation or research such as is proposed in the report.

It was with reluctance that I assented to the provision that I should appoint the proposed Board but the Committee deemed this the most feasible plan. In order that you may better understand what would probably follow your adoption of the resolution, I may add that several members of the initial board would probably be drawn from the membership of the Committee. I have discussed with several the matter of the director and find a strong sentiment that Dean M. E. Cooley would be an admirable man for the place, although he may not be available.

---

* This Report was approved by the Council of the Society and initiated the Investigation.

Your prompt reply will facilitate action.

Very truly yours,
Charles F. Scott,
President.

Will you please indicate on the enclosed postcard your official vote on the attached report Please send by letter suggestions.

F. L. Bishop,
Secretary.

Report

Pittsburgh, Pa., August 8, 1922.

To the Members of the Council.

Gentlemen:

Your committee appointed to study the development of the Society for the Promotion of Engineering Education and to formulate an answer to the question ''What can the Society do in a comprehensive way to develop, broaden and enrich engineering education'' begs leave to submit its report:

It may be well first to call attention to such general aspects of the question as have influenced your committee in reaching its conclusions. The probable future of engineering perhaps has had most influence. It will be accepted as a fact that the engineer of tomorrow will be called upon to take even a more important part than the engineer of today in great enterprises, both private and public. He will be called upon for general service in organization and leadership as well as for technical service in the solution of new problems (industrial, economic, governmental and social) which the engineering applications of science have produced. This means imagination, vision, the power to conceive and the ability to carry out great projects.

The problem of engineering education is to determine and to meet the progressive demands of a rapidly changing civilization. What constitutes these demands is a question being considered by educators, by engineering societies, by organizations of industries and public utilities and by others. Unfortunately, there has been almost no coördination of effort, and there is lack of agreement on even fundamental objectives. The first necessity then would seem to be an investigation to determine just what the facts are.

While knowledge of the facts is of course necessary before any constructive steps can be taken your committee believes that it is fully as important to develop high ideals of engineering education in both students and teachers. It is thought that through the immediate stimulation of individual teachers and individual institutions advancement may come in larger measure on the adoption of the recommendations with which this report concludes. The organization to carry out these recommendations should be directed by a man who has the confidence of the schools, of the profession, of the industries and of the public. He should be an inspiring speaker as one of his duties would be to visit engineering schools and meet both teachers and students. There should be associated with him other men who could assist in this work. With this general view of the conditions your committee lays before you its findings.

The question involves two fundamental inquiries:

A. What the engineer graduate should be.
B. What the training of the engineer student should be and the influence surrounding him.

In ascertaining *A* it will be necessary to study the functions of the engineer of the past and of the present time; and to try to conceive those of the future, keeping in mind the highest ideals of service to be rendered the public and the profession.

In determining *B* it will be necessary to define and express as clearly as may be those high and comprehensive ideals of service, that they may be readily comprehended by employers of engineer graduates, and by faculties and students.

Having determined *A* and *B* then comes the sublime duty of this Society to see to it that teachers, students, employers and the profession itself are all roused to the Society's enthusiastic support in making the investigations, in formulating the conclusions to be drawn from them, and in executing the plans evolved for the future of engineering education.

Recognizing the principle that to handle forces they must first be known in magnitude and direction after which they can be resolved and combined, your committee feels that the fundamental requirement is to investigate comprehensively the facts bearing on engineering education in its several fields and to arrange and present the results.

These fields are, first of all, civilization itself, after which may come the needs of the profession of engineering and the needs of industry,—the three together determining the type of engineer graduate required. Then may be considered the material to be wrought upon, namely, the student; and finally, the machinery of education, including curriculum, teaching staff, facilities and other factors of college life. With the results of these investigations clearly presented, it ought to be possible to determine the procedure which in the time available (4, 5 or 6 years) will best prepare the engineer graduate for his career.

As one result of these investigations there may follow the answer to another question, namely, whether the wide range of service which men of engineering training are called upon to perform makes desirable different types of engineering schools such as one producing broadly educated men and another producing highly trained specialists.

The foregoing illustrates the steps which to your committee seem essential. In order that they may be taken it is deemed necessary to establish an organization which may be called a Board of Investigation and Coördination. The instrumentalities of this Board would be a staff of investigators in charge of a director; and a body of counsellors embracing representatives from the several fields concerned in the investigation. There should, for example, be representatives from the U. S. Bureau of Education, the professions, the industries, the National Education Association and the public.

Your committee would therefore recommend:

I. That there be created within the Society a Board of Investigation and Coördination, consisting of five (5) members,* under whose general direction there shall be organized and conducted (*a*) an active campaign for the promotion of engineering education in light of the needs of the future as those needs may be developed; (*b*) there shall be coördinated as far as possible the activities of the various agencies interested in promoting engineering education; and (*c*) there shall be conducted research in engineering education.

---

* The membership was increased to nine by the addition of the President and Secretary of the Society and two non-engineering educators.

II. That there be authorized a Board of Counsellors consisting of representatives from the several fields to which engineering education is related, to advise and assist the Board of Investigation and Coördination.

III. That there be authorized a director, with an adequate staff, the director to be appointed by the Board of Investigation and Coördination, and when appointed to be ex-officio Chairman of the Board,* the Secretary of the Society to be ex-officio Secretary of the Board.

IV. That progress reports to the Society be published periodically in ENGINEERING EDUCATION, the bulletin of the Society.

V. That President Charles F. Scott be a member of the Board and have authority to appoint the other members; that the terms of the initial members be 5, 4, 3, 2 and 1 years respectively, the individual assignments being made by lot. That vacancies be filled by the Council on nominations made by the Board and that vacancies be created by the Council upon recommendation of the Board.

VI. That the objects (among others) for which the Board is created shall be considered to be:

1. To ascertain the facts in engineering education, such as concerns (*a*) teachers, their origin, training, experience and effectiveness; (*b*) teaching facilities; (*c*) curriculums; (*d*) students and graduates, their origin, training, experience and effectiveness.
2. To ascertain present and future requirements in the fields served by engineer graduates.
3. To present the facts and requirements for their bearing on the training of the engineer to the end that he may (*a*) develop himself and his profession; (*b*) realize and fulfill his obligation to society.
4. To maintain close contact with engineering schools enabling them to participate in the investigations; and reporting to them from time to time; to the end that the developments may be continuous from the initial contact between the colleges and the agencies of the Board.
5. To secure the necessary funds for these purposes.

(Signed) M. E. COOLEY,
J. H. DUNLAP,
D. C. JACKSON,
F. W. MCNAIR,
C. F. SCOTT, *Chairman.*

---

* The Director of Investigations did not serve as chairman.

PUBLICATIONS OF THE SOCIETY AND OF THE BOARD DURING THE PERIOD OF THE INVESTIGATION OF ENGINEERING EDUCATION

I. OF THE SOCIETY (See following page)

MONTHLY JOURNAL OF ENGINEERING EDUCATION and

ANNUAL PROCEEDINGS

These contained much of the material which later appeared in pamphlets and reports of the Board.

II. OF THE BOARD (See second following page).

Pamphlets (usually reprints) relating to

(*a*) The Investigation of Engineering Education.
(*b*) Technical Institutes.
(*c*) Summer Schools for Engineering Teachers—Selected Papers.

Volumes I and II—comprising many of the Pamphlets in (*a*) and (*b*) and additional material.

Other progress reports and relevant articles are listed in the accompanying Bibliography.

I. PUBLICATIONS OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

Prior to 1924 the annual Proceedings of the Society contained only the record of the Annual Convention while the monthly pamphlet, Engineering Education (Bulletin of the S P E E) included many of the papers presented at the Convention and much additional material.

About the time that the Investigation was begun a change was made. The ten monthly issues (which are now termed the Journal of Engineering Education) were bound in one volume and became the Annual Proceedings. The volume numbers differ but the paging is the same in pamphlets and Proceedings. The latter bear the date of the Convention they record.

	Monthly Pamphlet ENGINEERING EDUCATION Bulletin of S P E E		Annual Volume PROCEEDINGS	
Volume	No. 1 to	No. 10	Volume	Year
XII	Sept 1921–	June 1922	XXIX	1921
XIII	“ 1922–	“ 1923	XXX	1922
XIV	“ 1923–	“ 1924	XXXI	1923

The foregoing *Proceedings* contained only the record of the Annual Convention.

The subsequent *Proceedings* consist of the ten issues of the *Journal of Engineering Education* bound in a single volume.

	JOURNAL OF ENGINEERING EDUCATION			PROCEEDINGS	
New Series	No. 1 to	No. 10		Volume	Year
XV	Sept 1924–	June 1925	—making	XXXII	1924
XVI	“ 1925–	“ 1926	“	XXXIII	1925
XVII	“ 1926–	“ 1927	“	XXXIV	1926
XVIII	“ 1927–	“ 1928	“	XXXV	1927
XIX	“ 1928–	“ 1929	“	XXXVI	1928
XX	” 1929–	“ 1930	“	XXXVII	1929
XXI	“ 1930–	“ 1931	“	XXXVIII	1930
XXII	“ 1931–	“ 1932	“	XXXIX	1931
XXIII	“ 1932–	“ 1932	“	XL	1932
XXIV	“ 1933–	“ 1934	“	XLI	1933

II. PUBLICATIONS OF THE BOARD OF INVESTIGATION AND COORDINATION

Reports of the activities of the Board usually appeared first in the monthly and annual publications of the Society. Many of these reports were reprinted as pamphlets. Nearly all of this material has been assembled in the present Volumes I and II except the Selected Papers of the Summer School. Early progress reports are not included here but appear in the accompanying Bibliography.

(a) THE INVESTIGATION OF ENGINEERING EDUCATION

Reports by Board and Staff

Page

Report of the Chairman; Organization and Procedure 1930, C F Scott . . 1

*Summary of the Fact-Gathering Stages of the Investigation of Engineering Education, by H P Hammond, June 1926 17
  Proc v 34 p 52; also J Eng Ed Sept 1926

*Preliminary Report to the Board of Investigation and Coordination and the Society, by W E Wickenden, June 1926 52
  Proc v 34 p 22; also J Eng Ed Sept 1926

Address to Representatives of Engineering Colleges at Washington, D. C., on November 18, 1926 by Frank Aydelotte ....
  Proc v 34 p 533; also J Eng Ed Jan 1927

*Preliminary Report of the Board of Investigation and Coordination, November 1926 82
  Proc v 34 p 321; also J Eng Ed Dec 1926

*Second Report of the Board of Investigation and Coordination, June 1927 120
  Proc v 35 p 37; also J Eng Ed Sept 1928

Third Report of the Board of Investigation and Coordination, June 1929 142

Curriculum Revision in the Light of the Board's Recommendations, by W E Wickenden, November 1926 ....
  Proc v 34 p 792; also J Eng Ed Apr 1927

Final Report of the Director of Investigations, W E Wickenden, June 1933 1041

General Report of the Summer School for Engineering Teachers, 1927–1933, by H P Hammond 1117

*Report of Conference of Administrative Officers of Engineering Colleges, July 1933 1145
  Proc v 41 pp 117–175, 383–400; also J Eng Ed Oct 1933 Feb 1934

*Final Report of the Chairman, A Summary of Results, C F Scott, June 1934 1237
  Proc v 42 p 76; also J Eng Ed Sept 1934

---

* Indicates pamphlets are available (Dec. 1933) at Lancaster Press, Lancaster, Pa.

Data and Committee Reports

Page

*Bulletin 1, A Study of Engineering Students at the Time of Entrance .. 159
Proc v 34 p 83; also J Eng Ed Sept 1926
*Bulletin 2, A Study of Admissions and Eliminations of Students 193
Proc v 34 p 115; also J Eng Ed Sept 1926
*Bulletin 3, A Study of Engineering Graduates and Non-Graduate Former Students 226
Proc v 34 p 172; also J Eng Ed Sept 1926
*Bulletin 4, A Study of Engineering Teaching Personnel 272
Proc v 34 p 217; also J Eng Ed Oct 1926
*Bulletin 5, A Study of the Supplementary Activities of Engineering Colleges 318
Proc v 34 p 279; also J. Eng Ed Nov 1926
*Bulletin 6, A Study of the Costs of Engineering Education 340
Proc v 34 p 300; also J Eng Ed Nov 1926
*Bulletin 7, A Study of Engineering Degrees, November 1926 356
*Bulletin 8, A Study of Electrical Engineering Graduates (Eta Kappa Nu) November 1926 368
*Bulletin 9, A Summary of Opinions Concerning Engineering Curricula 388
Proc v 34 p 356; also J Eng Ed Nov 1926
*Bulletin 10, A Study of Engineering Curricula 426
Proc v 34 p 454; also J Eng Ed May 1927
*Bulletin 11, A Study of Evolutionary Trends in Engineering Curricula 522
Proc v 34 p 551; also J Eng Ed May 1927
*Bulletin 12, A Study of the Cooperative Method of Engineering Education 558
Proc v 34 p 669; also J Eng Ed May 1927
*Bulletin 13, Opinions of Professional Engineers Concerning Educational Policies and Practices 626
Proc v 35 p 215; also J Eng Ed Dec 1927
Bulletin 14, The Summer School for Engineering Teachers (the 1927 Sessions, with Selected Papers) ....
Proc v 35 pp 362, 521, 670; also J Eng Ed Jan Feb Mar 1928
*Bulletin 15, A Study of Placement Examinations 688
Proc v 36 p 25; also J Eng Ed Oct 1928
*Bulletin 16, A Comparative Study of Engineering Education in the United States and in Europe, by W E Wickenden June 1929 748
The Engineering Graduate in Industry; The National Industrial Conference Board Studies of 1924–1925 by A C Jewett 1016
Preliminary Report of the Committee on Economics 1031
1930 Survey of Engineering Education Supplement to J. Eng. Ed. Mar. 1931 1163

(b) TECHNICAL INSTITUTES

*A Study of Technical Institutes, February 1931, Part 2 of this Volume
*A Study of Technical Institutes, Summary Report, June 1931
*Report of Chairman (Condensed Summary), Part 1, pages 1262–1268

* Pamphlets available (Dec. 1933) from Lancaster Press, Lancaster, Pa.

(c) SUMMER SCHOOLS FOR ENGINEERING TEACHERS

Selected Papers

(Not included in Volumes I and II. Page numbers refer to monthly and annual publications.)

1927 Sessions—Mechanics

Note: Selected Papers of the two initial and simultaneous sessions were printed in full in Bulletin 14 (of the preceding series) which contains a comprehensive report of the proceedings. This includes many papers in abstract, both of technical and of general interest. Some of the latter are included with the Selected Papers in the following list.

Bulletin No. 14. (The Mechanics Sessions)

Proc v 35; also J Eng Ed Dec 1927 Jan Feb Mar 1928

What the College has Done for the Engineering Graduate. R E Doherty .... (Dec) 334†
Teaching the Fundamentals of Mechanics. W S Franklin (Jan) 381, 385
Applications of Mechanics to Electrical Engineering. V Karapetoff 386
The Importance of the Unpractical. J C Parker 409
Some Opportunities for Teachers of Mechanics. C F Scott 423
University Development in Europe and the United States. P R Kolbe 446
Mechanics of the Nineteenth Century as Revealed by Textbooks of the Period. E R Maurer .... (Feb) 526
Some General Laws of Learning. Curtis Merriman 534
Liberal Learning and Mechanical Training. Glenn Frank 540
The Historical Development of Mechanics. H F Moore 578
The Rôle of Mechanics in Electrical Engineering Curricula. Edward Bennett 593
A New Approach to the Study of Mechanics. Edward Bennett.. 597
Engineering Education in Russia. Stephan Timoshenko 603
History of Mechanics Before Newton. E W Rettger.... (Mar) 670
A Study of Methods of Teaching Mechanics. Curtis Merriman.. 703
Lessons from a Great Life (Newton). C S Slichter 707

1928 Sessions—Physics; Electrical Engineering

***Selected Papers No 1 (Physics)**

Proc v 36; also J Eng Ed Nov 1928

Our Debt to the Electricians of the Nineteenth Century. Henry Crew 329

***Selected Papers No 2 (Electrical Engineering)**

Proc v 36; also J Eng Ed Nov 1928

Historical Outline of the Electrical Units. A E Kennelly 229

Selected Papers No 3 (Reports of Committees)

Proc v 36; also J Eng Ed Dec 1928

Physics, seven reports 355
Electrical Engineering, ten reports 374

* Pamphlets available (Dec. 1933) from Lancaster Press, Lancaster, Pa.
† Page in monthly and annual publications.

	Page in Proceedings
***Selected Papers No 4 (Physics)**	
Proc v 36; also J Eng Ed Jan 1929	
Objectives for Undergraduate Courses in Physics for Engineeering Students. W S Franklin	421
Physics in Engineering Curricula; a Review of Present Conditions. A W Duff	426
Laws of Learning. W F Dearborn	428
Teaching the Fundamentals of Physics; Mechanics. O M Stewart	448
Teaching the Fundamentals of Physics; Heat. A W Duff	451
Teaching the Fundamentals of Physics; Electricity and Magnetism. W S Franklin	454
Teaching the Fundamentals of Physics; Light and Sound. O M Stewart	459
The Lecture, Class-discussion, and Laboratory in Physics Courses. A W Duff	462
The Lecture as a Teaching Medium. Sir John Adams	464
The Function of Laboratory Work in Physics Courses. A W Duff	465
Lecture-demonstrations in Teaching Physics. A W Duff	467
The Class-discussion Method in Physics. O M Stewart and W F Dearborn	471
Sectioning on the Basis of Ability. W F Dearborn	475
How May Physics Be Made of More Vital Interest? W L Severinghaus	477
Observations Concerning Teaching Methods Presented at the Summer School. W F Dearborn	487
***Selected Papers No 5 (Electrical Engineering)**	
Proc v 36; also J Eng Ed Apr 1929	
The Place of Electrical Engineering in Engineering Education. W E Wickenden	703
The Learning Process. G H Alderman	712
The Principles of Teaching. G H Alderman	717
Introduction to the Teaching of Electrical Engineering. C F Harding	721
The Teaching of the Fundamentals of Electro-dynamics. Edward Bennett	753
The Teaching of the Elements of Electrical Engineering: Circuits. W R Work	776
The Function of the Laboratory in Electrical Engineering Courses. H E Dyche	782
Michael Faraday. F L Bishop	790
The Westinghouse Company and Its Men. F A Merrick	803
The Engineer and Research. S. M. Kintner	806
Application of Economic Principles to the Design of Electrical Equipment. A M Dudley	811
Fundamental Principles in the Design of Electrical Equipment. R E Hellmund	819

1929 Session—Mechanical Engineering

Selected Papers No 6	
Proc v 37; also J Eng Ed Sept 1929	
James Watt. Ira N Hollis	46

	Page in Proceedings
The Industrial Revolution. J W Roe	78
A Resumé of Mechanical Engineering Since James Watt. W D Ennis	89
Selected Papers No 7	
Proc v 37; also J Eng Ed Nov 1929	
Reports of nine committees	159
Selected Papers No 8 (General Division)	
Proc v 37; also J Eng Ed Nov 1929	
Aims and Purposes of Mechanical Engineering Education. D S Kimball	274
College Personnel Methods. A A Potter	277
Organization of Courses in Mechanical Engineering Subjects for Non-mechanical Engineers. S W Dudley	285
The Mechanical Engineering Department; Organization, Management, Methods of Instruction, Cost of Operation. E F Miller	294
***Selected Papers No 9 (Heat Power Division)**	
Proc v 37; also J Eng Ed Dec 1929	
Purposes and Scope of Courses in Heat Engineering. A A Potter	355
Some Thoughts on the Teaching of Engineering Thermodynamics. G W Munro	366
Gas Cycles. F O Ellenwood	379
The Properties of Vapors. G W Munro	386
Vapor Cycles. F O Ellenwood	393
Fuels and Combustion. W J Wohlenberg	405
Selected Papers No 10	
Mechanical Engineering, Vol 51 (Am Soc Mech Eng) and (Timoshenko) vol 52	
The Fundamentals of Management Applied to Industrial Enterprises. L P Alford	964
A Thermodynamic Analysis of the Steady Flow of Fluids. C Harold Berry	816
Some Fundamental Principles of Material Handling. H V Coes	747
Factors Affecting Power Cost. C F Hirshfeld	842
Trends in Power-Plant Development in the United States and Europe. C F Hirshfeld	727
Modern Labor Relations and the Engineer. S A Lewisohn	736
Materials of Machine Construction. H F Moore	739
Recent Developments in the Application of Mechanics to Machine Design. S Timoshenko	607
Transactions (FSP), vol 52 (Am Soc Mech Eng)	
Economic Heat Transfer. W J Wohlenberg	351
Heat Reaction in the Boiler Furnace. W J Wohlenberg	177
***Selected Papers No 11 (Machine Design Division)**	
Proc v 37; also J Eng Ed Jan 1930	
Purposes and Scope of Courses in Mechanics of Machinery and Machine Design. O A Leutwiler	556
Classroom Methods in Machine Design. O A Leutwiler	560

Page in Proceedings

Applications of Mechanics to Machine Design. O A Leutwiler .. 563
Teaching of Materials in Machine Design. H F Moore 571
Training of Designers—Methods of Training. S W Dudley 580
Training of Designers—Qualities They Should Possess. H F Schmidt 586

*Selected Papers No 12 (Production Division)

Proc v 37; also J Eng Ed Feb 1930
Organization for Production Control. L P Alford 620
Basic Principles and Trends in Personnel Administration. F W Willard 627
Purposes and Scope of Shop Courses. O W Boston 648

1930 Sessions—Civil Engineering; Engineering Drawing and Descriptive Geometry

*Selected Papers No 13 (Civil Engineering)

Proc v 38; also J Eng Ed Sept 1930
The Enrichment of Experience in the Development of the Teacher. J C Tracy 53

Selected Papers No 14

Proc v 38; also J Eng Ed Nov Dec 1930 Jan 1931
Getting Students to Learn. F T Spaulding 220
Getting Students to Stay Taught. F T Spaulding 287
Can the Teacher Justify His Job? F T Spaulding 384

*Selected Papers No 15 (Historical)

Proc v 38; J Eng Ed Oct Nov 1930 Feb 1931
The History of the Flexure Formula. H F Moore 156
History of the Development of Graphical Representation. F G Higbee 237
The Development of Bridge Construction. P G Laurson 433

*Selected Papers No 16 (Miscellaneous)

Proc v 38; also J Eng Ed Sept Oct Dec 1930 Jan Apr 1931
The objectives of Courses in Drawing and Descriptive Geometry. T E French 72
Organization and Administration of the Drawing Department. H H Jordan 166
The Responsibility of the Engineering Teacher. W E Wickenden 280
Some Facts About the Scholastic Achievements of Engineering Students. H W Miller 371
Professional Ethics and Practices in Engineering. Anson Marston 559

Selected Papers No 17 (Civil Engineering)

Civil Engineering vol I (Am Soc Civil Eng)
Research Advances Civil Engineering. A D Flinn 14
Guiding Principles of the Activated Sludge Process. T C Hatton 31
Arc Welding on Steel Buildings. F P McKibben 37
Quest of Elasticity. H F Moore 171
Highway Transport Problems. Maxwell Halsey 184

	Page in Proceedings
Purifying Water for Domestic Use. R S Weston	197
Mississippi River—A National Flood Problem. J F Coleman	401
Movable Bridges. Otis E Hovey	595
Basic Principles of Concrete Making. F R McMillan	601
Logic of Engineering Diagnosis. Thaddeus Merriman	625
Researches in Concrete Aid the Engineer. H F Gonnerman	727
Highway Traffic Control. Maxwell Halsey	733

1931 Session—Mathematics

Selected Papers No 18 (Historical)

Proc v 39; also J Eng Ed Dec 1931

Outline of the History of Mathematics. R C Archibald	246

Selected Papers No 19 (Teaching)

Proc v 39; also J Eng Ed Dec 1931 Jan Feb 1932

The Teaching of Trigonometry for Engineers. E R Hedrick	299
College Algebra for Students of Engineering. W E Brooke	387
Analytic Geometry for Students of Engineering. W J Berry	392
Teaching the Calculus. E V Huntington	485

1932 Session—English

Selected Papers No 20

Proc v 40; also J Eng Ed Nov Dec 1932 Jan Feb 1933

English in Engineering Education. R P Baker	200
Problems of Administering English Work in Engineering Colleges. R P Baker	282
Technical Exposition for the General Reader. John Mills	352
What Does the Configurationist Say? E B Taylor	365
The Young Engineer and His English. R I Rees	479
The Art of Technical Writing. G A Stetson	491

1933 Session—Mining and Metallurgy

*Selected Papers No 21

Proc v 41; also J Eng Ed Sept Nov Dec 1933 Feb 1934

Purpose and Scope of Mining and Metallurgical Engineering Education. E A Holbrook	75
Historical Aspects of Mining and Metallurgical Engineering. T T Read	229
Summary of Status and Trends of Mining and Metallurgical Curricula. W B Plank	303
Vital Elements in the Training of Mining and Metallurgical Engineers. F A Thomson	310
The Relationship of General and Analytical Chemistry Courses to the Teaching of Metallurgy. E R Jette	401
The Place of the Social Sciences in the Training of Engineers. D D Lescohier	414

BIBLIOGRAPHY 1922–1933

PUBLICATIONS RELATING TO THE INVESTIGATION SUPPLEMENTARY TO VOLUMES I AND II

This Bibliography contains reference to preliminary and progress reports and to various addresses and articles relevant to the Investigation and its Supplementary Projects. It is selective and not exhaustive.

Items under the several heads are usually in chronological order.

PERIODICALS IN BIBLIOGRAPHY

Agri Eng	Agricultural Engineering
Biennial Survey of Education	Biennial Survey of Education in U. S.
Bur Ed Bul	U. S. Bureau of Education Bulletin
California Quar Secondary Ed	California Quarterly of Secondary Educacation Magazine
Central J	Central Journal of Engineering, Arnhem Holland
Civil Eng	Civil Engineering A S C E
Cleveland Eng	Cleveland Engineering
Cornell Civil Eng	Cornell Civil Engineering
El W	Electrical World
Elec Eng	Journal of American Institute of Electrical Engineers
Electric Journal	Electric Journal
Eng Foundation Pub	Engineering Foundation Publication
Eng N	Engineering News-Record
Engineers and Eng	Engineers and Engineering
Factory and Ind Management	Factory and Industrial Management
Foreman and Ind	Foreman and Industrial Executive Magazine
J A I E E	Journal of American Institute of Electrical Engineers
J Asso Eng Soc of St Louis	Journal of Associated Engineering Societies of St. Louis
J Eng Ed	Journal of Engineering Education S P E E
J Franklin Inst	Journal of the Franklin Institute
J of Higher Ed	Journal of Higher Education
J Western Soc of Eng	Journal of Western Society of Engineers
Mech Eng	Mechanical Engineering A S M E
Mich Tech	Michigan Technic
N Y Times	New York Times
Power	Power
Proc	Proceedings of S P E E
Proc A Assoc of Junior Colleges	Proceedings A of the Association of Junior Colleges
Proc A S C E	Proceedings of American Society of Civil Engineers
Proc 40th Conv Asso of L G C	Proceedings of the 40th Convention of the Association of Land Grant Colleges
Prof Eng	Professional Engineer

Ry Mech Eng	Railway Mechanical Engineering
School and Society	School and Society
Science	Science
Sibley J	Sibley Journal of Engineering, Cornell University
S P No. —	Selected Paper No. — of The Summer School Session of S P E E
S S 1927	Proceedings of the 1927 Summer School Session of the S P E E
Tech Rev	Technology Review
Trans A I E E	Transactions of American Inst. of Electrical Engineers
Trans Am Inst Chem Eng	Transactions of American Inst. of Chemical Engineers
Trans A S C E	Transactions of American Society of Civil Engineers
Trans A S M E	Transactions of American Society of Mechanical Engineers
Yale Scientific Magazine	Yale Scientific Magazine

AUTHORS IN BIBLIOGRAPHY

The letters at the bottom of the following pages are used for reference in this list of authors.

Page
Adams, Sir John .... *K*
Agg, T R .... *G*
Alderman, G H .... *K*
Alexander, M W .... *G*
Archibald, R C .... *F*
Barker, J W .... *K*
Bennett, Edward .... *C, D*
Bishop, F L .... *D, E, F, I*
Butler, G M .... *G, H*
Compton, K T .... *I*
Cooley, M E .... *B*
Crew, Henry .... *F*
Cushman, F .... *G*
Davis, R E .... *G*
Dearborn, W T .... *K*
Dick, Adelaide .... *H*
Doggett, C S .... *G*
Doherty, R E .... *D, F*
Dunlap, J H .... *B, H*
Ennis, W D .... *F*
Flinn, A D .... *B*
Frank, G .... *K*
Franklin, W S .... *D, K*
Gibbons, J O G .... *I*
Gladson, W N .... *G*
Hall, A V .... *C*
Hammond, H P ....*B, C, D, F, J, L*
Hayford, J F .... *B*
Henline, H H .... *D*
Higbee, F G .... *F, J, K*
Hollis, Ira N .... *F*
Hoad, W C .... *F*
Jackson, D C .... *B, C, H, I*
Jansky, C M .... *E*
Jewett, A C .... *G*
John, W C .... *D*
Karapetoff, V .... *C*
Kennelly, A E .... *F*
Kimball, D S .... *D, F, G, H, J*
Kolbe, P R .... *F*
Laurson, P G .... *F*
Leland, O M .... *C, D, H*
Lewis, W K .... *G*

Page
Lyford, O S .... *F*
Mann, C R .... *D*
Maurer, E R .... *F*
McNair, F W .... *B*
Merriman, C .... *K*
Moore, H F .... *F*
Nelson, J R .... *B*
Ogur, E .... *J*
Pegram, G B .... *B, D*
Potter, A A .....*B, D, E, G, H, I, J*
Provine, L H .... *G*
Raymond, W G .... *H*
Read, T T .... *F*
Rees, R I .... *E, I*
Remmers, H H .... *J*
Rettger, E W .... *F*
Roe, J W .... *F*
Sackett, R L ....*E, F, G, F, J*
Scott, C F ....*A, B, C, E, H, I, J, K*
Seaton, R A .... *G*
Shane, A .... *G*
Slichter, C S .... *F*
Smith, E D .... *D*
Spahr, R H .... *F, G, L*
Spaulding, F T .... *K*
Stetson, G A .... *C*
Stillwell, L B .... *B*
Swain, P W .... *K*
Taylor, E B .... *K*
Timoshenko, S .... *D*
Tracy, J C .... *K*
Turneaure , F E .... *G*
Walker, C L .... *E*
Walker, P F .... *B*
Wallace, L W .... *I*
Walters, R .... *D*
Watts, A S .... *G*
White, A H .... *B*
Wickenden, W E
A, B, C, D, E, F, G, H, I, J, K, L
Wildes, K L .... *C*
Woods, B M .... *G*
Zook, G F .... *G*

TITLES IN BIBLIOGRAPHY

Board of Investigation and Coördination

1. Inception, organization, activities. (Chronologically listed)
   - The Society's Biggest Problem, C F Scott—J Eng Ed Jan 1922 p 220
   - Appointment of Development Committee, June 1922—Proc v 30 p 10; also J Eng Ed Sept 1922 p 22
   - Report of Development Committee—J Eng Ed Sept 1922 p 27 see Appendix
   - Letters from 26 Engineering Colleges regarding Report—J Eng Ed Nov Dec 1922 pp 120 177
   - Membership of Board—Proc v 32 p 90; also J Eng Ed June 1923
   - Secretary's Report 1923, summary; correspondence with Carnegie Corporation regarding funds—Proc v 31 p 22; also J Eng Ed Oct 1923 p 74
   - The Engineer as a Leader in Business, W E Wickenden—Proc v 31 p 94; also J Eng Ed Sept 1923 p 15 (Note. The presentation of this paper led to the choice of Mr Wickenden as Director of Investigations)
   - Grant of Funds by Carnegie Corporation, Oct 31 1923—Proc v 32 p 90; also J Eng Ed Sept Oct 1923
   - W E Wickenden accepts as Director—J Eng Ed Nov 1923 p 105
   - ''The Story up to Date'' by Chairman—J Eng Ed Nov 1923 p 106
   - Statement of Plans—J Eng Ed Dec 1923 p 150
   - Outline of Project, by Director—J Eng Ed Jan 1924 p 218
   - Program of Board, by Director—J Eng Ed Feb 1924
   - Year Book, summary of activities—J Eng Ed Mar 1924 p 305
   - Annual Report of Chairman, 1924—Proc v 32 p 90; also J Eng Ed Sept 1924
   - Objectives and Outline of Procedures—Proc v 32 p 315; also J Eng Ed Jan 1925
   - Report to Carnegie Corporation, Dec 1924—Proc v 32 p 411; also J Eng Ed Feb 1925
   - Secretary's Report 1924—Proc v 32 p 148; also J Eng Ed Oct 1924
   - Annual Report of Chairman (Past, present and future) 1925—Proc v 33 p 25; also J Eng Ed Sept 1925
   - Annual Report of Chairman (end of Fact-gathering; new financing) 1926—Proc v 34 p 15; also J Eng Ed Sept 1926
   - Secretary's Report, 1928—Proc v 36 p 101; also J Eng Ed Sept 1928
   - Annual Report of Chairman, 1929—Proc v 37 p 23; also J Eng Ed Sept 1929
   - Secretary's Report, 1929—Proc v 37 p 32; also J Eng Ed Sept 1929
   - Secretary's Report, 1930—Proc v 38 p 34; also J Eng Ed Sept 1930
   - Secretary's Report, 1932—Proc v 40 p 31; also J Eng Ed Sept 1932
   - Final Report of Board to Council June 1934—Proc v 42 p 8; also J Eng Ed Sept 1934

2. Preliminary Plans and Progress Reports, by Director Wickenden and Associate Director Hammond
   - ''Notes from the Field,''—J Eng Ed May 1924 p 506
   - Progress and Plans—Proc v 32 p 9; also J Eng Ed Sept 1924

Committee Appointments—Proc v 32 p 165; also J Eng Ed Nov 1924
Reports—Proc v 32 pp 324 330 414; also J Eng Ed Jan Feb 1925
Projects Undertaken—Proc v 32 p 493; also J Eng Ed Mar 1925
Reports—Proc v 33 pp 30 169 179; also J Eng Ed Sept Nov 1925
Publication Program announced—Proc v 34 pp 21 436; also J Eng Ed Sept Dec 1926
See Summer Schools

3. Reports of the Investigation—

See Publications of the Board, preceding this Bibliography

4. General Articles

The New Project for the S P E E, C F Scott—Trans A S C E v 86 1923 p 1238
Coöperation between Engineering Colleges and the Board, J R Nelson —Proc v 31 p 68; also J Eng Ed Oct 1923
Board of Investigation and Coördination—Discussion at Convention by M E Cooley, J H Dunlap, D C Jackson, F W McNair, J F Hayford, P F Walker—Proc v 31 p 52 1923
Address on Work of Board, before A S M E, W E Wickenden—J Eng Ed Jan 1924 p 218
Why Investigate Engineering Education? A A Potter—Proc v 32 p 311; also J Eng Ed Jan 1925
A Study of Engineering Education, C L Walker—Cornell Civil Eng v 33 Apr 1925 p 141
Origin and History of the Present Study of Engineering Education, C L Walker—Sibley J v 39 May 1925 p 332
Investigation by the Society, G B Pegram—Proc v 33 p 1; also J Eng Ed Sept 1925
Surveys in Higher Education, G B Pegram (Presidential Address)—Proc v 34 p 4; also J Eng Ed Sept 1926
The Second Report on Engineering Education, W E Wickenden—School and Society v 26 July 30 1927 p 147
A New Investigation under the Auspices of the Society (Technical Institutes), W E Wickenden—Proc v 35 p 211; also J Eng Ed Dec 1927
The Investigation of Engineering Education (Summary) C F Scott—J of Higher Ed v 1 Feb 1930 p 91
Engineering Education (Brief Review of the Investigation) Stillwell and Flinn—Eng Foundation Pub Apr 1928 p 10
Future Organization and Activity, with report by Committee on Policy, W E Wickenden—Proc v 36 p 161; also J Eng Ed Oct 1928

Chemical Engineering

Study of Chemical Engineering Education—Trans Am Inst Chem Eng v 19 1927 p 207
Chemical Engineering Education in the U S, A H White—Trans Am Inst Chem Eng v 21 1929 p 55

Civil Engineering

The New Project of the S P E E, Chas F Scott—Trans A S C E 1923 p 1244; also Proc A S C E 1923 p 498
Educating the Civil Engineer, H P Hammond—Civil Eng Nov 1931 p 1269
See Summer School, 1930 Session

Conference of Administrative Officers, July 1933

Resume of the Session, G A Stetson—Proc v 41 p 62; also J Eng Ed Sept 1933

Report of Conference, Papers presented—Proc v 41 pp 117–175, 383–400, also J Eng Ed Oct 1933 Feb 1934 (also a pamphlet reprint)

Coöperative Courses—

Development in Coöperative Engineering Courses, R L Sackett—Eng N v 90 June 14 1923 p 1050

The Coöperative Method of Engineering Education, W E Wickenden (Bulletin 12)—Proc v 34 p 669; also J Eng Ed Mar 1927

Coöperative Courses—Their Development and Operating Principles (Bulletin 12) K L Wildes—Trans A I E E v 49 July 1930 p 1086

Curriculum—Undergraduate

Length and Content of Curriculum, Division of Deans and Administrative Officers at Ann Arbor Jan 1924—Program, J Eng Ed Jan 1924 p 241; Report, Proc v 32 p 360; also J Eng Ed Jan 1925

Curriculum Revision in the Light of the Board's Recommendations, W E Wickenden—Proc v 34 p 742; also J Eng Ed Apr 1927

The Engineering Curriculum, H P Hammond—Proc v 35 p 57; also J Eng Ed Sept 1927

Making the Engineer Articulate, W E Wickenden—Engineers and Eng v 47 Sept 1930 p 233

English as an Essential Part of the Engineering Curriculum, A V Hall—J Eng Ed Jan 1932 p 416

Curriculum—Graduate

Graduate Study in the Engineering Schools, D C Jackson—Proc v 35 p 125; also J Eng Ed Oct 1927

The Post College Education of Engineers, Edward Bennett—J A I E E v 48 Apr 1929 p 310

Function of Administrative Office with Regard to Graduate Work, D C Jackson—Proc v 41 p 140; also J Eng Ed Oct 1933

Degrees, Engineering

A Logical Engineering Degree, O M Leland—Proc 40th Convention Association of Land Grant Colleges Nov 1926 p 270; also Proc v 34 p 447; also J Eng Ed Jan 1927

Engineering Degrees, H P Hammond—Proc v 33 p 669; also J Eng Ed June 1928

Economic Aspects, see Social

Electrical Engineering

The Place of Electrical Engineering in Engineering Education, W E Wickenden—(S P No 5) Proc v 36 p 703; also J Eng Ed Apr 1929

Report Committee on Education, A I E E

W E Wickenden, Chairman—Trans A I E E v 42 1923 p 790; v 43 1924 p 1100

Edward Bennett, Chairman—Trans A I E E v 48 1929 p 1334; also J A I E E Sept 1929

Applications of Mechanics to Electrical Engineering, V Karapetoff—(S S 1927) Proc v 35 p 386; also J Eng Ed Jan 1928

See Summer School, 1928 Session

Engineering Colleges

Problems of Accrediting Engineering Colleges, H P Hammond—Proc v 41 p 170; also J Eng Ed Oct 1933

Engineering Education

Education for the Functional Divisions of Engineering, Edward Bennett—J A I E E Nov 1923 p 1145

Engineering Education (Sums up 12 points of Mann Investigation) C R Mann—J Asso Eng Soc of St Louis v 3 Sept 1924

Engineering Education, W E Wickenden—J Asso Eng Soc of St Louis v 3 No 12 Dec 1924 p 1

Engineering Students' Rise (Address before Alumni at Columbia) W E Wickenden—N Y Times Dec 18 1925 p 30

The Engineering Scene, W E Wickenden—Proc v 33 p 433; also J Eng Ed Jan 1926; also Tech Rev v 28 p 433

Surveys in Higher Education, G B Pegram (Presidential Address)—Proc v 34 p 4; also J Eng Ed Sept 1926 p 4

Engineering Education, R Walters—School and Society v 24 Dec 1926

Higher Education and Engineering Education, W C John—Proc v 34 p 366; also J Eng Ed Dec 1926 p 399

Engineering Education, Its History and Prospects, Henry H Henline—J A I E E v 45 1926 p 1147

What the College has Done for the Engineering Graduate, R E Doherty—(S S 1927) Proc v 35 p 334; also J Eng Ed Dec 1927

Trends in Engineering Education, A A Potter—Ry Mech Eng v 101 July 1927 p 427

Policies of Engineering Education, W E Wickenden—Proc A S C E v 53 1927 p 282

The Rôle of Mechanics in Electrical Engineering Curricula, E Bennett—(S S 1927) Proc v 35 p 593; also J Eng Ed 1928

A New Approach to the Study of Mechanics, E Bennett—(S S 1927) Proc v 35 p 597; also J Eng Ed Feb 1928

Engineering Education in Russia, S Timoshenko—(S S 1927) Proc v 35 p 603; also J Eng Ed Feb 1928

Education and Training as applied to the Engineer, F L Bishop—Mech Eng v 50 Sept 1928 p 692

Objectives of Undergraduate courses in Physics. W S Franklin—(S P No 4) Proc v 36 p 421; also J Eng Ed Jan 1929

The Place of Electrical Engineering in Engineering Education. W E Wickenden—(S P No 5) Proc v 36 p 703; also J Eng Ed Apr 1929

Engineering Education and Its Future, W E Wickenden—J Western Soc of Eng v 34 July 1929 p 380; also Factory and Ind Management v 78 July 1929 p 80

Aims and Purposes of Mechanical Engineering Education. D S Kimball—(S P No 8) Proc v 37 p 274; also J Eng Ed Nov 1929

Engineering Education, A A Potter—Mech Eng v 52 Apr 1930 p 503

Engineering Education, F L Bishop—Biennial Survey of Education in U S 1928–30 Chap 16

History of the Development of Engineering Education in U S, F L Bishop—Central J Eng 1930 (Buvani Ingenieursbureau Buvani) Arnhem Holland

Engineers, Managers and Engineering Education, W E Wickenden and E D Smith—Proc v 39 p 846; also J Eng Ed June 1932

The Engineer as a Leader in Business, W E Wickenden—Proc A I E E 1932 p 94

See Progress in Engineering Education

English, See Summer School, 1932 Session

Enrollment

Enrollment: Records of Student Enrollment are usually presented biannually by W C John of the U S Office of Education and appear in the first part of the Proceedings and a fall issue of the Journal

European Engineering Education

Industrial Education in Great Britain, R L Sackett—Mech Eng v 46 No 3 Mar 1924 p 145
A News Letter from Paris, W E Wickenden—Proc v 32 p 574; also J Eng Ed Apr 1925 p 574
Notes on Engineering Education in Great Britain, W E Wickenden—Proc v 32 p 580; also J Eng Ed Apr 1925
Technical Training in Europe, W E Wickenden—Elec W v 85 June 27 1925 p 1417
Foreign Engineering Education, W E Wickenden—School and Society v 22 Aug 29 1925 p 276
Engineering Education East of the Rhine, W E Wickenden—Proc v 33 p 107; also J Eng Ed Oct 1925
The Technical Institute; European Examples and Their Significance for American Education, W E Wickenden—Mech Eng v 51 June 1929 p 451
Engineering Research in Germany, A A Potter—Power v 70 July 2 1929 p 31

Examinations

A Study of Placement Examinations (Bulletin 15)—Proc v 36 p 25; also Eng Ed v 19 Sept 1928 p 25

Extension Courses in Engineering, C M Jansky—Proc v 34 p 410; also J Eng Ed Dec 1926

Graduates (and Former Students)

The Engineer of Tomorrow, C F Scott—Mech Eng v 45 Feb 1923 p 138
Seminars for Practicing Engineers—Trans A I E E v 45 May 1926 p 602
Engineering Graduates and Non-Graduate Former Students (Bulletin 3) R L Sackett—Proc v 34 p 172; also J Eng Ed Oct 1926
Returns of Questionnaire Sent to Graduates of the Classes of '22 '23 '24 College of Eng Cornell Univy (digest and trends), C L Walker—Cornell Civil Eng v 35 p 36 Nov 1926; also Sibley J v 40 p 136 Nov 1926
Returns of Questionnaire sent to Graduates of the classes of 1871–1921, College of Eng Cornell Univ (analysis and trends), C L Walker—Cornell Civil Eng v 35 p 65 Dec 1926
A Study of Former Students, College of Eng Cornell Univ (opinions, experience and careers), C L Walker—Cornell Civil Eng v 35 p 143 Dec 1926; also Sibley J v 41 p 86 Mar 1927
Finds College Study Pays in Later Life, R I Rees—N Y Times May 8 1929 p 38

Historical Papers

- University Development in Europe and the United States, P R Kolbe—(S S 1927) Proc v 35 p 446; also J Eng Ed Jan 1928
- Mechanics of the Nineteenth Century as Revealed by Textbooks of the Period, E R Maurer—(S S 1927) Proc v 35 p 526; also J Eng Ed Feb 1928
- The Historical Development of Mechanics, H F Moore—(S S 1927) Proc v 35 p 578; also J Eng Ed Feb 1928
- History of Mechanics Before Newton, E W Rettger—(S S 1927) Proc v 35 p 670; also J Eng Ed Mar 1928
- Lessons from a Great Life (Newton), C S Slichter—(S S 1927) Proc v 35 p 707; also J Eng Ed Mar 1928
- Our Debt to the Electricians of the Nineteenth Century. Henry Crew—(S P No 1) Proc v 36 p 329; also J Eng Ed Nov 1928
- Historical Outline of the Electrical Units. A E Kennelly—(S P No 2) Proc v 36 p 229; also J Eng Ed Nov 1928
- Michael Faraday. F L Bishop—(S P No 5) Proc v 36 p 790; also J Eng Ed Apr 1929
- James Watt. Ira N Hollis—(S P No 6) Proc v 37 p 46; also J Eng Ed Sept 1929
- The Industrial Revolution. J W Roe—(S P No 6) Proc v 37 p 78; also J Eng Ed Sept 1929
- A Resumé of Mechanical Engineering Since James Watt. W D Ennis—(S P No 6) Proc v 37 p 89; also J Eng Ed Sept 1929
- History of the Flexure Formula. H F Moore—(S P No 15) Proc v 38 p 156; also J Eng Ed Oct 1930
- History of the Development of Graphical Representation. F G Higbee—(S P No 15) Proc v 38 p 237; also J Eng Ed Nov 1930
- The Development of Bridge Construction. P G Laurson—(S P No 15) Proc v 38 p 433; also J Eng Ed Feb 1931
- Outline of the History of Mathematics. R C Archibald—(S P No 18) Proc v 39 p 246; also J Eng Ed Dec 1931
- Historical Aspects of Mining and Metallurgical Engineering. T T Read—(S P No 21) Proc v 41 p 229; also J Eng Ed Nov 1933
- Promotion of Engineering Education in the last 40 Years, H P Hammond—Proc v 41 p 44; also J Eng Ed Sept 1933

Industries and Engineering Schools

- The Engineering School and the Industries (Joint meeting A S M E and S P E E) D S Kimball and others—Mech Eng v 44 p 7 Jan 1922
- The Engineer as a Leader in Business, W E Wickenden—Proc v 31 p 94; also J Eng Ed Sept 1923 p 15
- Current Studies in Engineering Education, W C Hoad—Mich Tech v 38 May 1925 p 20
- Training Engineers for Responsibility, W E Wickenden—Cleveland Eng v 22 Dec 26 1929; also Prof Eng v 15 Apr 1930 p 7
- Where Do Foremen Come From? R H Spahr—The Foreman and Ind Mar 1931
- Industry vs Technical Education, Conference at Lehigh University—Elec Eng Jan 1931 p 8
- Educational Aspects of Engineering and Management, R E Doherty—Trans A I E E v 51 p 848; also J A I E E June 1932 p 76
- National Industrial Conference Board, S P E E Papers
  - The Engineer as a Leader in Industry, O S Lyford—Proc v 31 1923 p 136

The Engineer Graduate in Industry, A C Jewett—Proc v 32 1924 p 424
The Problem of Engineering Education from the Standpoint of American Industry, M W Alexander—Proc v 34 1926 p 586
See Footnotes on pp 9 and 1016

National Industrial Conference Board (New York City)—Reports of Investigations

Engineering Education and American Industry, Special Report No 25, written by Oliver S Lyford, published Aug 1923
Technical Education and the Paper and Pulp Industry an unnumbered pamphlet prepared by A C Jewett, published Oct 1924
Technical Education and the Rubber Industry, an unnumbered pamphlet prepared by A C Jewett, published Nov 1924
Technical Education and the Textile Industry, an unnumbered pamphlet prepared by A C Jewett, published Dec 1924
Technical Education and the Chemical Industry, an unnumbered pamphlet prepared by A C Jewett, published in 1925
Technical Education and the Metal Trades Industry, an unnumbered pamphlet prepared by A C Jewett, published in 1925
Technical Education and the Electrical Manufacturing Industry, an unnumbered pamphlet prepared by A C Jewett, published in 1925

Junior College

Engineering Education on the Junior College Level, R H Spahr—Proc A Assoc of Junior Colleges Nov 20 1929
Junior College Movement on the West Coast. B M Woods—Proc v 40 p 415; also J Eng Ed Feb 1933
Function of the Junior College in Engineering Education. R E Davis—Proc v 40 p 427; also J Eng Ed Feb 1933
Some Implications of the Junior College Movement. Geo F Zook—Proc v 41 p 162; also J Eng Ed Oct 1933

Land Grant Colleges

Land Grant College Education Part 4, Engineering and Mechanic Arts, W C John (Including chapters by A A Potter F E Turneaure R A Seaton W N Gladson W K Lewis G M Butler L H Provine T R Agg R L Sackett A S Watts C S Doggett A Shane F Cushman)—Bur Ed Bul 1925 No 5
The Land Grant College Survey, A A Potter—Proc v 36 p 306; also J Eng Ed Nov 1928

Mathematics, see Summer School, 1931 Session

Mechanical Engineering

Summer School 1929 Editorial Appraisal—Mech Eng v 51 p 711
Aims and Purposes of Mechanical Engineering Education, D S Kimball—Proc v 37 p 274; also J Eng Ed Nov 1929
See Summer School, 1929 Session

Mining and Metallurgy

Mining Engineering Education since 1910. G M Butler—Proc v 32; also J Eng Ed Dec 1924
See Summer School, 1933 Session

National Industrial Conference Board

See Industries

Problems of Engineering Schools

Engineering Schools Fall Short of Modern Needs, J H Dunlap—Engineering N v 89 Aug 10 1922 p 224

Needed: New Life in the Colleges, D C Jackson—School and Society v 30 Sept 28 1929 p 415

The Need for Broader Engineering Education, G W Patterson—Mich Tech v 42 Jan 1929

Problems Before Engineering Teachers, A A Potter—Proc v 32 p 2; also J Eng Ed Sept 1924

Professions; Professional

Professional Societies, See Societies

Professional Status of the Engineer, W E Wickenden—Civil Eng v 1 1930 p 23

Professional Organizations and Professional Schools, W E Wickenden and Adelaide Dick—Proc v 32 p 224; also J Eng Ed Dec 1924

College Education and Professional Training, W E Wickenden—Proc v 32 p 180; also J Eng Ed Nov 1924

Progress in Engineering Education

The Future of Engineering Education (Presidential Address), C F Scott —Proc v 30 p 12; also J Eng Ed Sept 1922

Preparing the Engineer for the New Era, J H Dunlap—J Eng Ed Oct 1922 p 48

The Outlook for the Engineering Colleges in the Middle West, W G Raymond—Proc A S C E v 49 1923 p 498

The Progress and Promise of Engineering, D S Kimball—J Franklin Inst v 199 Jan 1925

The Engineering College—Its Opportunity for Service, A A Potter—Proc v 33 p 4; also J Eng Ed Sept 1925

Are We Making Progress? O M Leland—Proc v 35 p 1; also J Eng Ed Sept 1927

Progress in the Study of Engineering Education—A Summary, W E Wickenden—Eng N v 96 Jan 1926 p 73

Extension of Engineering Education in the Metropolitan Area, W E Wickenden—Proc v 35 p 515; also J Eng Ed Jan 1928

The Changing Emphasis in Engineering Education, R L Sackett—Proc v 36 p 9; also J Eng Ed Sept 1928

Where are We Headed in Engineering Education? P W Swain—Power v 70 July 30 1929 p 171

American Year Book, see annual volumes, Education, Engineering

Research

Research in Engineering Education, H P Hammond—Mech Eng v 47 May 1925 p 386

Engineering Research as an Aid to Good Teaching, A A Potter—Proc v 32 p 571; also J Eng Ed Apr 1925

Research Relations between Engineering Colleges and Industry, W E Wickenden—Trans A I E E v 45 1926 p 600; also J A I E E Oct 1926

The Function of Research in Engineering Education, D C Jackson—Science v 74 No 1912 Aug 21 1931 p 183

Research at Colleges and Universities of North America, Report of Committee of Engineering—J Eng Ed Mar 1930 Supplement

Research in Engineering Colleges, 7 Papers and Reports at 1932 Annual Meeting—Proc v 40 pp 67 93 to 161

Social and Other Aspects of Engineering

Engineering Training and Modern Life, C F Scott—El W v 81 Jan 13 1923 p 120

Educating Engineers in Economics, W E Wickenden—Eng N v 100 June 14 1928 p 938

The Engineering College—Its Opportunity for Service (Presidential Address) A A Potter—Proc v 33 p 4; also J Eng Ed Sept 1925

Educating Engineers in Economics, W E Wickenden—Eng N v 100 June 14 1928 p 938

Religious Significance of Scientific (Engineering) Achievements (Contribution to Symposium on Science and Religion) C F Scott—Report of 6th Ecumenical Conference of Methodist Church 1931; also Electric Journal Feb 1932; also Yale Scientific Magazine June 1932

Cultural Aspects of Engineering Education, K T Compton—Proc v 40 1932 p 69

The Engineer in a Changing Society, W E Wickenden—Elec Eng July 1932 p 465

Engineering Education in the Light of Changed Social and Economic Conditions, W E Wickenden—Proc v 41 p 148; also J Eng Ed Oct 1933

Societies—Relation of Engineering Schools and Engineering Societies

Meeting of Representatives of Engineering Societies and S P E E, June 1923—J Eng Ed Dec 1923 p 199

Conference on the Relations of the Engineering Schools and the National Engineering Societies, W E Wickenden—J Eng Ed June 1924 p 561

Professional Organizations and Professional Schools, W E Wickenden and Adelaide Dick—Proc v 32 p 224; also J Eng Ed Dec 1924

Education and Professional Societies, F L Bishop—Proc v 35 p 213; also J Eng Ed Dec 1927

What National Engineering Societies Can Do for Engineering Education, W E Wickenden—Power v 66 Dec 13 1927 p 932; also Mech Eng v 50 Feb 1928 p 119

Report of Committee on Economic Status of the Engineer (A S M E Report which led to E C P D)—Mech Eng v 53 1931 pp 631 817

Coöperation of S P E E with Other Engineering Societies (E C P D), R I Rees—Proc v 40 p 36; also J Eng Ed Sept 1932

Engineers' Council for Professional Development (E C P D)—Proc v 40 p 387; also J Eng Ed Jan 1933

Student Selection and Elimination

The Problem of Selection in Engineering Education, A A Potter—Proc v 32 p 88; also J Eng Ed Oct 1924

Sixty Percent of Engineering Students Drop Out, E Ogur—Power v 63 Mar 16 1926 p 421

Engineering Students Dropping Out, J O G Gibbons—Power v 63 May 18 1926

A Comparison of Engineering Freshmen over an Interval of Ten Years (Tests of Purdue used) H H Remmers—School and Society v 31 May 10 1930 p 652

Engineering Educational Standards, L W Wallace—Agri Eng v 12 Sept 1931

Summer Schools, General

A Summer School (English) for Engineering Teachers, W E Wickenden—Proc v 33 p 253; see also J Eng Ed Dec 1925

- Summer Schools, Their Aims and Methods, W E Wickenden—Proc v 34 p 777; also J Eng Ed Apr 1927

S P E E Summer Schools for Engineering Teachers (See Publications of the Board, Bulletin 14 and Selected Papers, preceding this Bibliography also General Report of Summer Schools p 1117)

- Announcement of Inauguration of Summer Schools, C F Scott—Proc v 34 p 661; also J Eng Ed Mar 1927
- Summer Schools, H P Hammond—Proc A S C E v 53 1927 p 208
- A Practical Step Toward Improved Methods of Teaching, H P Hammond —Proc v 36 p 109; also J Eng Ed Sept 1928
- Success of the Summer School, D S Kimball—Proc v 36 p 693; also J Eng Ed Apr 1929
- Report to Society; Review and Appraisal June 1931, H P Hammond—Proc v 39 p 39; also J Eng Ed Sept 1931

S P E E Summer Schools, 1927–1933

- 1927 Sessions, Engineering Mechanics, H P Hammond (Author also of following reports for other years unless otherwise noted)—Proc v 34 p 833 v 35 p 11; also J Eng Ed May Sept 1927
  - Impressions of Session on Mechanics, R L Sackett—Proc v 35 p 25; also J Eng Ed Sept 1927
  - Bulletin 14 (See Publications of the Board preceding this Bibliography)
- 1928 Sessions, Electrical Engineering and Physics—Proc v 35 pp 528 670 860 v 36 p 109; also J Eng Ed Feb Apr May Sept 1928
  - Summer Schools for Electrical Engineering and Physics, R L Sackett —Proc v 35 p 775; also J Eng Ed Apr 1927
  - Selected Papers Nos 1 2 3 4 5 (See Publications of the Board, preceding this Bibliography)
- 1929 Session, Mechanical Engineering—Proc v 36 pp 132 404 413 695 v 37 p 159; also J Eng Ed Sept Dec 1928 Jan Apr Oct 1929
  - Article—School and Society v 30 Aug 24 1929 p 270
  - Article—Factory and Ind Management v 78 Sept 1930 p 397
  - Article—School and Society v 30 Aug 1929 p 270
  - Article, A A Potter—Proc v 37 p 37; also J Eng Ed Sept 1929
  - Editorial Appraisal—Mech Eng v 51 Sept 1929 p 711
  - Selected Papers Nos 6 7 8 9 10 11 12 (See Publications of the Board preceding this Bibliography)
- 1930 Sessions, Civil Engineering and Engineering Drawing—Proc v 37 pp 24 712 v 38 pp 41 48; also J Eng Ed Sept 1929 Mar Sept 1930
  - Society Sponsors Summer School—Proc A S C E v 56 1930 p 144
  - Article, School and Society v 31 Feb 1930 p 198
  - The Engineering-Drawing Session, F G Higbee—Mech Eng v 52 Sept 1930 p 871
  - Selected Papers Nos 13 14 15 16 17 (See Publications of the Board preceding this Bibliography)
- 1931 Sessions, Chemical Engineering and Mathematics—Proc v 38 pp 263 500 602; v 39 p 39; also J Eng Ed Dec 1930 Mar May Sept 1931
  - Selected Papers (Mathematics) Nos 18 19 (See Publications of the Board preceding this Bibliography)

1932 Sessions, Economics and English—Proc v 39 pp 443 740; also J Eng Ed Feb May 1932

Selected Papers (English) No 20 (See Publications of the Board preceding this Bibliography)

1933 Session, Mining and Metallurgy

Selected Papers No 21 (See Publications of the Board preceding this Bibliography)

(Note: For 1933 Conference of Administrative Officers see Conference)

Teaching, Methods of,

Teaching the Fundamentals of Mechanics, W S Franklin—(S S 1927) Proc v 35 pp 381 385; also J Eng Ed Jan 1928
Some Opportunities for Teachers of Mechanics, C F Scott—(S S 1927) Proc v 35 p 423; also J Eng Ed Jan 1928
Some General Laws of Learning, C Merriman—(S S 1927) Proc v 35 p 534; also J Eng Ed Feb 1928
Liberal Learning and Mechanical Training, G Frank—(S S 1927) Proc v 35 p 540; also J Eng Ed Feb 1928
A Study of Methods of Teaching Mechanics, C Merriman—(S S 1927) Proc v 35 p 703; also J Eng Ed Mar 1928
Laws of Learning. W T Dearborn—(S P No 4) Proc v 36 p 428; also J Eng Ed Jan 1929
The Lecture as a Teaching Medium. Sir John Adams—(S P No 4) Proc v 36 p 464; also J Eng Ed Jan 1929
The Learning Process. G H Alderman—(S P No 5) Proc v 36 p 712; also J Eng Ed Apr 1929
Learning and Teaching; Three Lectures. F T Spaulding—(S P No 14) Proc v 38 pp 220, 287, 384; also J Eng Ed Nov Dec 1930 Jan 1931
What does the Configurationist Say? E B Taylor—(S P No 20) Proc v 40 p 365; also J Eng Ed Jan 1933
Teaching Mathematics; Four Papers—(S P No 19) Proc v 39 pp 299, 387, 393, 485; also J Eng Ed Dec 1931 Jan Feb 1932

Teaching Personnel

The Enrichment of Experience in the Development of the Teacher. J C Tracy—(S P No 13) Proc v 38 p 53; also J Eng Ed Sept 1930
The Responsibility of the Engineering Teacher, W E Wickenden—(S P No 13) Proc v 38 p 280; also J Eng Ed v 21 Dec 1930
Selection and Development of Faculties, J W Barker—Proc v 41 p 135; also J Eng Ed Oct 1933

Technical Institutes

A New Investigation under the Auspices of the Society (Technical Institutes) W E Wickenden—Proc v 35 p 211; also J Eng Ed Dec 1927
The Investigation of Non-College Technical Education, W E Wickenden—Proc v 36 p 134; also J Eng Ed Sept 1928
Where Are We Headed in Technical Education? W E Wickenden—Power v 49 Feb 19 1929
The Technical Institute, European Examples and Their Significance for American Education, W E Wickenden—Mech Eng v 51 June 1929 p 451; Discussion p 678
Summary of the Study of Technical Institutes, W E Wickenden—Trans A S M E v 52 (Management paper 7) 1930 p 63

Technical Institute Education in America, R H Spahr—Proc v 38 p 487; also J Eng Ed Mar 1931

The Need for Semi-Professional Education, R H Spahr—California Quar Secondary Ed Jan 1932

A Study of Technical Institutes, R H Spahr—Ind Ed Mag Feb 1932

Vocational Guidance

The Educational and Vocational Guidance of Engineering Students and Graduates (Paper read before Engineering Extension Convention and Industrial Conference, Penn State College May 1925), H P Hammond—Proc v 32 p 735; also J Eng Ed v 15 June 1925

On Choice of Engineering as a Profession and Its Possibilities, W E Wickenden—Mech Eng v 48 July 1926 p 769

Engineering—A Culture, a Career—Pamphlet for Preparatory School Students issued by Engineering Foundation, 1932 See Proc v 40 p 230; also J Eng Ed Nov 32

INDEX

INVESTIGATION OF ENGINEERING EDUCATION

Volume I and Volume II, Part 1

(Part 2 Technical Institutes is independently Paged and Indexed)

Lists of pertinent Bulletins and Reports accompany important titles, *e.g.*, Admissions, Curricula.

The context of an item may be found by locating it in the Table of Contents by its page number.

For additional material relevant to the Investigation consult the Bibliography preceding this Index.

Paging is continuous; in Volume II the forematter begins with page lv, and the text with page 1041.

Aachen, institute at, 800, 803
Abteilung of German University, 957
Abturient (examinations), 953
Accrediting engineering colleges, 654, 656, 1159, 1162
Administration, training for, see Management
Administrative Officers, conference of (1933), 1145–1162
Admission, Bulletins, and Reports concerning
  Bulletin 2, Admissions and Eliminations of Engineering Students, xix, xliii, 193–225
  Bulletin 10, Part I, Graphical Summary of Entrance Requirements, xlviii, 429–439
    Part III, Summary and Analysis of Entrance Requirements, xxv, 446–453
  Summary Report, 25–27
  Report of Board, xvii, 94–98
  Report of Committee, 180
  1930 Survey, 1164–1170
Admission, to advanced standing, 95, 190
  concours of (France), 838
  German institutions, 953, 964
  levels of (England), 899
  limitations of (France), 836, 837
Admissions, selective, 99, 100
  1930 Survey, 1165, 1170
Agassiz at Harvard, 814
Age of entering students, 162, 188
Age groups, changes in, 1052
Agriculture, 1049
Aims of technical education, 1001
Alsis, 869
Alexander, M. W., 615, 617, 1060
American Engineering Education, Bulletin 16, xxxii, 748–1015; Historical development, xxxiv, 807–823; Appraisal and comparison, xl, 1000–1015. See Technical Institutes. See 1256.
  aims of, 1001
  curriculum of, 1004
  dominant type of, 1000
  national system, without plan, 1000
  quantity production, 1002
  research in, 1008
  teachers, status of, 1010
Anderson's college (1796), 778, 789
Antioch College, coöperative, 564
Appell, Prof. P., 830

Apprenticeship (British), 775, 889–893
"Approved" engineering colleges, 654–657, 1159, 1162
Aptitude and training tests, 727
Aptitude vs. training, 709
Arcueil, 769
Armstrong College, 789
Army Alpha test, 706, 707
Arts colleges, recruitment from, 117
Associate membership examination by British Societies, 944, 945
Associateships, college (British), 927
Association of Teachers, British, 937
Attendance at Summer School for Engineering Teachers, 1121, 1128
Augsburg, 800
Austria, early schools, 795

Baccalaureat, 826, 828, 829
Bachelor of Technology, 360
Baker, Sir Benjamin, 777
Baldwin, Stanley, 790
Balfour Committee report, 946
Battersea polytechnic, 904, 918
Bauakademie at Berlin, 795, 797, 798
Baugewerkschulen, 953, 986–992
Bell Telephone system, engineering in, 1062
Benoit, 765
Bergakademie at Freiberg, 760, 794, 795, 816
Bergschulen (school of mining), 953, 993, 994
Berlin, *Banakademie* at, 795, 797, 798
Beuth at Charlottenburg, 798
Bibliography of engineering education (1922–1933), 1287
  of the coöperative method, 614–625
  of placement examinations, 741
Bichat, Dean, 865
Bigelow, Dr. Jacob, 816
Birkbeck, Dr. George, work of, 778
Bishop, F. L., 1240
Board of Investigation and Coordination: see Bibliography—
  appointment, 2, 5
  personnel: the Board and Staff, v, 5, lviii
  preliminary report of, Nov. 1926, xvi, 82–119
  problem of, 7
  publications of, 1280
  recommendations of, 1252
  reports of and to the Board, see Publications and Bibliography preceding this Index
  second report of (June, 1927), xvii, 120–141
  summary of activities, see Preface, Vol. II, also 1237
  third report of (June, 1929), xviii, 142–157
Bochum in the Ruhr, 994
Bohemian early schools, 795
Borough Polytechnic Institute (London), 929
Breslau, 800
Brigham, C. C., 724
Bristol University, 788, 892
British, see Engineering education; Great Britain
  industry, origins and traditions of, 772
Brixton, School of Building at, 920, 923, 933
Brown University, 814
Brunswick, Collegium Carolinum at, 800
Budgeting and finance (1933), 1150
Building construction (French), 869
Bulletins of the Investigation, see Publications, 1281
Business of students' fathers, 163, 164, 188

Cambridge, University of, engineering curricula of, 911
  fees and costs at, 904
  function and organization, 895
Cameralia, 793
Capitalism, 1055
"Capitalization grants," 779
Canadian engineering schools, 206
Carnegie Corporation, 3, 4, 1120, 1128, 1237
Carnegie Foundation, 2, 1043
Certificates and diplomas, national (British), 925–928
Certification to profession, 1114
Chalmers Technical Institute at Gothenburg, 954
Chandler Scientific School, 810, 813
Chandler at Columbia, 817

Character development in coöperative plan, 608
Charlottenburg, 797–805
Chaumat, Prof., 862
Chefs de travaux, 834
Chemical engineering, curricula in,
      nature of, 659
    trends in, 531
  engineers consulted, 659–662
  entrance requirements, 438, 439, 446–453
  graduation requirements, xxvii, 438, 439, 509–520
    specific subjects, 514–521
  at Massachusetts Institute of Technology, 564, 570
  relations with profession, 661
  shop instruction in, 660
  specialization in, 660
Chemistry at Mulhouse, 869
Chemistry, placement examinations in, 714, 741
Chemistry, aptitude and training tests, 694–740
Chemists, German, influence of on technical education, 800
Chemnitz, 954
Choice of course, 184, 191, 192
  of engineering, see Guidance
Cincinnati, University of, 616, 618, 621
City and Guilds of London Institute, 781, 787, 906–910, 927, 928
Civil engineering, chairs at Glasgow and Edinburgh, 785, 786
  curriculum, nature of, 663
    trends in, 327
  engineers consulted, 663–668
  entrance requirements, 430, 431 446–453
  graduation requirements, xxv, 430, 431, 455–468
    specific subjects, 461–468
  relations with professions, 667
  Rensselaer, curriculum in (1849), 813
  specialization, 664
  surveying, 666
Civil Engineers, see Institution of Civil Engineers
Classical curricula commended, 827
Cöthen, Polytechnic School at, 954
College men in industry, see Graduates
College shops, elimination of, 585
Columbia, School of Mines, 817
  six year course, 1086
Committees coöperating in this Investigation, vi–xiv
  on admissions and eliminations, 194
  on coöperative method, 560
  on costs of education, 341
  on economics, 1031
  on students and graduates, 162, 228
  on supplementary services of the colleges, 319, 341
  on teaching personnel, 273
Compensation, see Salaries
Concours (France), 829, 840–843
Conference of Administrative Officers (1933), 1145–1162
Conférence in French schools, 844
Conservatoire des Arts et Métiers, 763, 868
Continution of education, see Post-Scholastic
Continuation schools (German), 949–950
Contributors, 15, 16, lxiii
Cooper, William John, 1163
Coöperative method of engineering education, Bulletin 12, xxviii, l, 558–625
  plan of this Investigation, 3, 7, 1042
Coördination of related subjects, 49
  of sciences and technical subjects, 411
  means to bring about, 412, 424
Cornell University, influence of, 817
  shop practice at, 820
Cornog and Stoddard, 714, 718, 741
Corps des Ponts et Chaussées, 758, 759
Correspondence courses, 339
Costs of engineering education, Bulletin 6, xxii, xlvi, 340–355
  summary of data, 31
  see Tuition
Costs of instruction at coöperative schools, 586
Costs and fees in British schools, 904, 935
    in French schools, 846
    in German schools, 977, 996
Council on education tests, 707
Cours in French schools, 843
Creative intellectual effort, 146
Credentials for non-degree courses (British), 924, 925

Cultural content of curricula, 42, 405–409
  opinions of teachers as to, 406, 419
  opinions of graduates, 242
Cultural interests of graduates, types of, 245
Curricula (Engineering): Bulletins and Reports relating to
  Bulletin 3. Opinions of graduates on effectiveness, 238–243, 266–268
  Bulletin 8. Opinions of electrical graduates, 378–384
  Bulletin 9. Summary of opinions of graduates, engineers and teachers, xxiii, xlviii, 388–425
  Bulletin 10. Requirements for entrance and for graduation, xxv, xlviii, 426–521
  Bulletin 11. Evolutionary trends, xxviii, 1, 522–557
  Bulletin 13. Opinions of engineers, xxx, li, 632–649, 658–687
  Bulletin 16. Engineering education in the United States and Europe (including numerous curricula), xxxii–xli, 748–1015. See Curricula, European.
  Summary of Fact gathering, xvi, 20, 32–49
  1st Report of Director, 59, 71–80
  1st Report of Board, xvi, 84–92
  2d Report of Board, xviii, 122–140
  3d Report of Board, xviii, 147–152
  Final Report of Director, 1090
  Final Report of Chairman, 1246
  1930 Survey, 1171–1189
Curricula, American, 1004
  characteristics of present, 550
  changes (1926–1930), 1172
  chemical engineering, 531, 659
  civil engineering, 327, 663
  comparison with pre-professional, 553
  coöperative program, as alternative, 79
  coördination of sciences and technical subjects in, 411
  correspondence courses, 339
  cultural content of, 405–407, 419
  data, tables of, 555–557
  differentiation in, 39, 147–153, 391, 415, 638
  discussion of, 1067
  diversity of, 86, 390–396
  divided, 123–124, see Unified vs. divided
  economic content of, 400, 418
  economics, need for, 381, 382
  electrical engineering, 378–384, 530, 556, 669
  evolution of, 33, 533–538, 544
  evolutionary process in, xxviii, 541–554
  evolutionary trends of, 522–557
    discussion and graphs, 526–541
  functional group of, suggested, 394
  functional vs. technical divisions of, 48, 416, 640–642
  fundamental elements of (graph), 40–44
  fundamentals in, 399, 400, 417
    swing toward, 396
  general qualities of undergraduates, 554
  graduates' comment on, 242, 267–268
  graduation requirements, 440–444
  longer, question of, 131–141
  mechanical engineering, 529, 674
  mining engineering, 528, 681, 682
    mineral technology, 684–685
  modern foreign languages in, 407, 420
  opinions concerning, discussion of, 390–413
    summary of, 388–425
    synthesis of, 413
  organization of, 34
    graph of, 37
  partial, value of, 197
  purposes of, 240
  qualities, general, 554
  reduction and revision of, 382
  requirements in, changes in, 533–538
    English, 533
    foreign languages, 533
    mathematics, 535
    physical sciences, 535
    social and language studies, 534, 538
    specific engineering subjects, 537

    technical (general) subjects, 536, 538
    total of, 1870 and to-day, 540
  scope of, xvii, 109–118
  selection in, principles of, 147–152
  sequences of, 34, 37
  specialization in, 39, 74, 1075
    limitations of, 393
  opinions of teachers as to, 393, 415, 416
  standards, synthesis of, 441
  structure of, 84–89
  time allotments (average) in, 539
  trends in evolution of, 522–557
    discussion and graphs, 526–541
    results of analysis, 556–557
  undergraduate, 84–89, 138
  unity of, 34, 37, 123, see Unified vs. divided
Curricula, European, 1004
  British local institutions, 920–924
    secondary schools, 885–886
    universities, 904–913
  French secondary schools, 827
    technical schools, higher, xxxvi, 849–874
  German higher and middle schools, xxxvii, 985–994
    secondary schools, 950–951
    universities, 970–977

Danzig, university at, 800
Dartmouth, 810, 813, 1086
Darmstadt, *hochschule* at, 799
''Datsch,'' see Deutscher Ausschuss fur Technisches Schulwesen
Degrees, Bulletins and Reports concerning
  Bulletin 7, Engineering Degrees, xxiii, xlvii, 356–367
  Bulletin 10, Engineering Curricula (Graduation Requirements) 426–521
  Summary Report, 50, 359–365
Degrees, existing confusion, 362
  evening courses, 324, 325
  first, 359–362
  graduate (advanced), 323, 334, 362, 364–367
  held by teachers, 284, 315
  practices and trends, 358–362
  propriety of the, 364
  titles and abbreviations, 357
Degrees (British), 902–904, 916
Degrees (Swiss), 804
Deutscher Auschuss fur Technisches Schulwesen (*Datsch*), 754 955
  activities of (chart), 956
  creation of, 802
  significance, 899
Deutsches Museum of Munich, 999
Development Committee, report of, 2, 8, see Appendix, 1274
Differentiation of curricula, 147–153, 390, 638
Diploma examination (German), 965, 968
Diplomas, college (British), 927
  national, 925
Diplomas and titles (French), 847
Director of Investigation, see Wickenden
Divided program, 123–124
Doctorate (France), 847
Doubs school of horology, 869
Dresden, *hochschule* at, 799
Durham, technical education at, 789

Earnings of graduates, 232–234, 261, 590
    analysis of, 262
  of Coöperative courses, 590
  of Eta Kappa Nu, 377
  initial in 1929, 1228
  and teachers, 278, 310
Earnings of students before admission, 166, 189
  of students (coöperative), 581
  of teachers, see Teachers, salaries
Eaton, Amos, at Rensselaer, 810
Eberhart, Professor, 793
Ecole Brequet, 873–874
Ecole Centrale des Arts et Manufactures, 762, 765–767, 857–859
Ecole Centrale Lyonnaise, 768, 769, 848, 860
Ecole d'Ingenieurs of *Lausanne,* 807
Ecole des Mines, 760, 817, 856, 857
Ecole d'Ingenieurs (Marseilles), 768
Ecole Nationale d'Arts et Metiers, 764
Ecole Polytechnique, advanced work at, 762, 839, 840, 851, 853

Ecole des Ponts et Chaussées, 758, 852–856
Ecole Speciale des Travaux Publics, 848, 863, 869
Ecole Supérieure d'Aeronantique et de Construction Mechanique, 770
Ecole des Travaux Publics, 761, 766
Ecole Speciale des Travaux Publics, 769
Ecole Supérieure d'Electricité, 769, 848, 861
Ecole Turgot, 831
Ecoles d'Arts et Metiers, 764, 765, 768, 842, 848, 869–873
Ecoles Centrales, 761, 766
Ecoles des Mines, 768, 769, 848, 860
Ecoles professionelles, 831
Economic aspects of coöperative plan, 609
  content of curricula, 99, 1031
  phases of engineering, 822, 1048
  problems, 1035
  status of teachers, 277, see salaries
Economics, committee report, 1031–1039, 1249
Economics in curriculum, 90, 381–383, 400–402
  methods of teaching, 1036
  opinions on, 402, 418
Edinburgh, 786, 787, 790
Education, see Engineering Education
Educational choices, basis of, 168–169
  demand, 132
  efficiency, considerations of, 130–133
  mission (Mosely), 791
  policies and practices, opinions regarding, Bulletin 13, xxx, li, 626–687
    changes in (1926–1930), 1172
  service, types of, 110
Educational policies, changes (1926–1930), 1172
Eggleston at Columbia, 817
Electives, chemical engineering, 517, 520
  civil engineering, 465, 468
  electrical engineering, 505, 508
  mechanical engineering, 491, 494
  mining engineering, 477, 480
Electrical Engineering, curricula in, nature of, 669
    trends in, 530, 556
  engineers consulted, xxxi, 668–673, see Eta Kappa Nu
  entrance requirements, 436, 437, 446–453
  Eta Kappa Nu studies, xxiii, 368–387
  in Europe, 890, 929, 971–976, 987
  graduation requirements, xxvii, 436, 437, 495–508
  relations with profession, 671
  shop instruction, 670
  specialization, 670
Electrical graduates, a study of, xxiii, xlvii, 368–387
  occupations and earnings, 370–378
  continuation studies, 384–387
Electrical Engineers, Institution of, examination, 945
Electrotechnics (French), 869
Eliminations, see Admission
  charts, 202, 1159
Elliott, E. C., 1152, 1161
Employment information (1930), 1221
  opportunities (1929), 1228
Endowments, data on, 345–355
''Engineer,'' derivation of the word, 755
Engineer, what does he do?, 1057
Engineer's work and training, scope of, 1056
Engineering, types of activity, 109
  National conceptions of, 755
Engineering, British university schools of, 893–917
Engineering colleges, accrediting of, 654, 656, 1159, 1162
  aims, 1094
  duty re admissions, 212
  effectiveness, 238
  facilities and standards, 115
  functions and scope, 60, 213
  ideals to be sought by, 213
  motivation of students in, 1073
  personnel problems in, 65–71
  present status of, 129
  recognition of, see accrediting of
  recruitment from arts colleges, 117
  research in, 31, 821, 1098
  supplementary activities of, 30,

        Bulletin 5, xxii, xlvi, 318–339
    undergraduate status, 57, 64, 116
Engineering course and vocational training, 1054
Engineering curricula, see Curricula
Engineering education, aims and process, 1070
    adaptation of program in, 131
    administration and management in, 46
    advanced studies in, 131, 135
    as a whole, 1269
    in America, see American Engineering Education
    assimilation of, by universities, 813
    in Central Europe, xxxix, 947–999
    colleges, see Engineering Colleges
    comparative study of, in the United States and Europe, xxxii, 748–1015, 1256
    complexity of, 1270
    contemporary movements in, 821
    coöperative, 558–625
    costs of, 31, 58, 340–355
        per student per year, 345, 354, 355
        summary tables and diagrams, 350–355
        unit costs in dollars, 355
    cultural content of, 42
    curricula, see Curricula
    curriculum in, question of longer, 133–141
    defect, and virtue of, 808
    definition of, 122
    early educational processes, 343
    economic content of, 44
    economic conditions, effects on (1933), 1156
    in Europe, 22, xxxii, 748–1015
    expenditures for, 354, 355
    facilities and standards of colleges, 115
    financial outlook (1933), 1150
    formative epoch, 545
    in France, xxxv, 824–878
        history of, 758–772
        influence of, 773
        National Educational System, 824–832
        Revolution, effect of, on, 761
    fundamental elements, 635
    future of, 12
    future work in, organization for, 80
    in Germany, xxxix, 947–999
    history of, xxxiv, 792–805
    graduate, see Graduate
    in Great Britain, xxxvi, 879–946
        history of, xxxiii, 772–792
        period of rapid growth in, 788
    guiding agency needed, 1090
    guiding influence in, 822
    historical development of, xxxii–xxxv, 755–823
        France, 758–772
        Great Britain, 772–792
        German states, 792–806
        Switzerland, 806–807
        United States, 807–823
    income for, 352
    inflexibility of, 76
    investigation of, see Investigation
    investment devoted to, 350
    junior college in scheme of, 56, 57, 1071, 1154, 1162
    objectives of, 112, 1080–1085
    orientation of, 1272
    origins and characteristics, 807
    non-collegiate, see Technical Institutes
    period of expansion of, leaders in, 816
    period of germination in, 809
    Perronnet, father of, 758
    pioneer efforts in, 810
    post-graduate, see Graduate work
    post-scholastic education, see Post-scholastic
    preparatory education for, 130
    professional phase of, 1102
    programs, types needed, 113
    scientific grounding for, 130
    scope of, 109–119
    selective principle in, 145
    sequence of studies in, 131
    shop courses in, 47
    social conditions, effects on, 1156
    State, the, relation to, 1159, 1162
    status of (1933), 1149
    survey of (1930), 1163–1236
    time economy, 131
    trend from practical toward scientific training in, 820
    turning point in (United States), 815

- a unified vs. a divided process in, 34, 37, 123–133, 1070, 1071
- in United States and Europe, xxxii–xli, 748–1015

Engineering graduates, see Graduates

Engineering profession, attitude toward education, 631, 1102
- influence of (British), 940
  - (French), 874
  - (German), 998

Engineering school, place of, in social progress, 823
- first (United States), 811

Engineering schools as selective institutions, 1077

Engineering societies, Bulletin 13, data supplied by, 626
- coöperation with schools, 654, 823, 1112, 1271, lxii
- influence of, 650–657, 823
- post-college education, 1113, see Post-scholastic

Engineering students, see Students

Engineering teachers, see Teachers

England, see Engineering Education in Great Britain

English, aptitude in training tests, 702, 727, 730
- importance of, 380
- for entrance, 451
- graduation requirements, 461, 473, 487, 501, 514

Enrollment of coöperative students, 566
- of graduate students, 322, 333
- in 1930 survey, 1165–1167

Enrollment in German technical universities, 977, 978

Entering students, see Students

Entrance conditions, analysis of, 217–218
- in mathematics, effect of, 219

Entrance requirements, see Admission
- 1930 Survey, 1171

Essen, 998, 999

Esslingen, 988

Eta Kappa Nu alumni, business connections of, 371
- earnings of, 377
- opinions on curriculum, 378–384
- study after graduation, 384–387

Eta Kappa Nu Association, study of electrical graduates, 368–387

European education, 748–1015

Evening courses with degrees, 324, 306
- without degrees, 325, 337

Ewing, Sir Alfred, 789

Examinations, professional (British), 943

Examining agencies for non-degree courses (British), 924–925

Examinations in German universities, 967–970
- in secondary schools, 953

Examinations, British, compared with American, 900–902
- in lower schools, 886
- by professional Institutions, 943, 944
- ranking by, 901

Exchange of professors, 301

Experience in industry, programs of, for graduates, 118

Extra-mural courses, 339

Eyrolles, Leon, School in Paris, 769

Fachschule, creation of the, 797

Fact-gathering stages of investigation, summary, xv, 17–51

Faculties, see Teachers
- selection and development of, 1151, 1161

Faculty committees, vi–xiv

Father of engineering education, Perronnet, 758

Faraday House, 892, 904

Fees, see Costs and Fees; see Tuition

Fellowships, 323, 335

Finsbury Technical College, 781, 782

Firth College, Sheffield, 788

Ford, Henry, 1049

Foreword, iii

Foreign language, aptitude test, 702, 728, 731, 733, 736
- decreased requirements in, 533
- for entrance, 452, 453
- graduation requirements, 463, 476, 489, 503, 516
- use and value of, 647–649

Fortbildungschule, 949

Fowler, Sir John, on pupilage, 776, 802

France, engineering education in, xxxv, 824–878
- historical development of, xxxii, 758–772
- influence in education, 770

Freiberg, *Bergakademie* at, 760, 794, 816

French language, see Foreign Languages
  Revolution, effect of, 761
Freshman, see Students
''Freshman week,'' 183 (1930 Survey), 1171
  year, engineering in, 185–186
  methods of study, 1101
Functional group of curricula, 394
  opinions on, 395, 396, 416
Functional types of activity for graduates, 248–250
Functional vs. technical divisions of curricula, 640–642
Fundamentals in curricula, 635
  comments on, 400
  swing toward, 396
    opinions as to, 399, 417
Funds, see Contributors

Gardiner, R. H. (1821), 810, 815
Gas engineering, at Glasgow, 932
German Committee for Technical Education, 145, 955
German States, education, technical, xxxix, 947–999
  historical development, xxxiv, 792–806
Gewerbe-akademie and *institut*, 798
Gewerbeschulen, 953
Gide on technical education, 793
Gifted students, work of, 102–104
Glasgow, Royal Technical College at, 778, 789, 913, 914
  courses at, 931, 932
  diploma of, 928
  sandwich plan at, 892
Gothenberg, Institute at, 954
Graduates (Engineering) Bulletins and Reports concerning.
  Bulletin 3, Engineering graduates and non-graduate former students, xx, xliv, 226–271
  Bulletin 8, Group of Electrical Engineering graduates (Eta Kappa Nu), xxiii, xlvii, 368–387
  Bulletin 13, Opinions of Engineers on educational policies and practices, xxx, li, 626–687
  Report of Fact-finding, 19, 27
    of Director, on further training, 117
  Report of Chairman, 1248
  National Industrial Conference Board, 9, 10, 1016–1030
  1930 Survey—Placement and Demand, 1212–1228
Graduate work, administration of, 1153, 1189
  courses, 322–333
    number and quality (1930), 1184
  degrees, see Degrees
  post-scholastic, see Post-scholastic
  resident, 75, 117, 123, 146, 1069, 1106
    attendance, 322, (1929) 1164, 1167
  Schools and industry, 1105, 1106
Graduates, careers of, 27
  coöperative, courses and careers, 589
  demand for, 27, 1238
  earnings, 261, 590, 1228
  engineering and business, 1038
  from high schools, 220
  in industry, 1016–1030
  occupations of, see Occupations
  personnel problems, 1153
  positions, how obtained, 235, 262
    analysis of, 1021
  programs in industry, 118
  salaries, see Earnings of Graduates
  training of, further, see Post-Scholastic Education
  transition to active life, 132
  unemployed (1933), 1153
Graduation requirements, 32, 440–445
  graphic summaries of, 429–439
  private and public institutions 443
  summary and analysis of, xxv xlvii, 454–521
Graduation per 100 admitted, 202, 203, 1169
Grashof, Professor, report in 1864, 801
Great Britain, see Engineering Education in
Greene, B. F. at Rensselaer, 812, 813
Grenoble, 835, 869
Guidance, before admission, 95, 172–180
  of graduates in choosing positions, 248
  of high school students, 172–180
  of students, 183–188

  summary of problems of, 178–180
  1930 Survey, 1170
Guillet, M., 837, 858, 875
Guilds of London, 781
Gymnasium (German), 950

Hale, Benjamin (1824), 810
Halifax Technical College, 928
Hamburg (Germany), 849, 986, 996
Hammond, H. P., Associate Director, v, 6
  Accrediting engineering colleges, 1159, 1162
  Summary of fact-gathering, xv, 17–51
  Bulletin 15, Placement Examinations, 688–747
Hammond, H. P., Director of Summer Schools, 7
  Summary Report on Summer Schools, 1117–1144
  Report of Conference of Administrative Officers, 1145
Hanover, *hochschule* at, 799
Harvard, 800, 814, 1086
Heriot-Watt College, 790, 884
High-School students, 166–167, 172–180, 190
  graduates, statistics, 220
Higher education, financial outlook (1933), 1150
  intensive forms of, 1013
Higher technical education in Central Europe, 947–999
  in England and Scotland, 879–946
  in France, 824–878
  in the United States, 1000–1015
Historical development, see Engineering education
"*Hochschule,*" significance of term, 803
Hochschulen, data on, 954
Hochschulen technische and the universities, 803
  rise of, 794–799
  rising prestige of, 802
Hogg, Quintin (1865), 780
Honours and degrees (British), 902–904
Home environment of Freshmen, 163, 188, 189
Horsford, Eben, 800, 814
Human side of education (Germany), 980
Humanistic studies, 148
Huxley, 781, 784, 787, 790
Hydraulics (Stuttgart), 992

Imperial College, South Kensington, 787, 788, 927
Income for engineering education, 347, 352, 353, 355
Incomes of teachers, 277, 286, 307–310, insert, 316
Industrial engineering, 1064
  experience (coöperative), 576
  firms (coöperative plan), 559, 580, 582, 604
  progress (German), 801
  schools (German), xxxix, 953, 981–996
Industry (British) origins and traditions of, 772
Industry, engineering graduate in, 118, 1016–1030
  Orientation to, 608–609
  status of student in, 584
Ingénieur d'Arts et Metiers, degree of, 832
Ingénieur-docteur, degree of, 847
Ingénieur du Conservatoire des Arts et Metiers, diploma of, 868
Ingénieur des Industries Electro-Mechaniques, diploma of, 874
Institut Industriel du Nord (Lille), 768, 769
Institut Technique, 835
Instituts techniques, 768
Institutes of universities (France), 834
Institutes at Nancy, 835, 848, 865–867
Institution of Civil Engineers, London, 765
  associate membership examination, 944
  influence of, on training, 766
  origin and purpose of, 774, 1111
  report on education, 777
  statement of Sir Benjamin Baker, 777
    of Sir John Fowler, 776
Intermediate goal for non-graduation students, 100
Interrogateurs (French), 834, 844
Investigation of Engineering Education, 1 (See Board of)
  aim and spirit, 1041
  brief: summarizing results, 1237
  coöperating agencies in, 7

  coöperative plan employed in, 3, 7, 1042
  inception of, 1, 1237
  fact-gathering stages of, 17–51
  funds for, 2, see Contributors
  contributors to, 15
  objectives of, 11
  organization, plan of, 17, 18
  publications, 1280
  studies constituting, 19–22
  summary of, see Preface, Vol. II
Investment for engineering education, 345–355
Iowa placement examinations and tests, 690, 707, 730, 740–742
Italy, state planning, 1055

Jackson, D. C., v, 2, 1153, 1162
Janet, Professor, 862
Jenkyn, Fleming, 776, 787
Jewett, A. C., report on graduates in industry, 1016–1030
Jewett, F. B., 1106
John, W. C., 426, 1163
Jordan, H. H., Chairman, vi, 194
Joy, at Columbia, work of, 817
Junior college, the, 56, 57, 1071, 1154, 1162
Junior technical school (British), 887–889

Kaiser Wilhelm Institute, 802
Karlsruhe, 796
  curricula at, 971–976
Kelvin, 785
King's College, 785, 787, 904
Krupp gift for research, 803

Labor saving machinery, 1050
Laboratory teaching, development of, 818, 819
  first (France), 764
  in Germany, 805, 961
Laboratories, use of for outside work, 287, 317
Lafayette College, 564
Lamblardie, 761
Lamme, B. G., 1106
Land Grant act (1862), See Morrill
Langlie, T. A., 741, 742
Language, See foreign language
Lausanne, 807
Lawrence Scientific School at Harvard, 800, 814
Le Chatelier, 837, 852
Lecture courses (German), 961
  10

Lehr-und lern-freiheit, 795, 798, 804, 977
Lemon, A. C., 709, 743
Library facilities (German), 961
Licensure for engineers, 1058, 1110, 1159, 1162
Liebig, influence of, 800
Lincoln Technical School, 921
Livery companies of London, 781
Load, see Teaching, load
Local technical institutions (British), xxxvii, 917–938
London County Council, schools, 917, 923
London polytechnics, 780, 904
Loughborough College, 893, 928
Lycée, function and plan, 826, 827
Lyford, O. S., paper by, 10

Magnus, Sir Philip, 782
Management, training for, 46, 403, 418, 642, 1007, 1063, 1065
  engineer's limitations in, 1061
  in Germany, 979
  trend of graduates to, 232
Manchester, Municipal College of Technology, 790, 896, 922, 928
  engineering curricula of, 914–915
Mann, C. R., 2, 691, 1048, 1150, 1161
Mann, Horace, 815
Mansart's bridge, 758
Mascart, initiative of, 770
Maschinenbanschule, 986–989
Mason College (Birmingham), 788
Massachusetts Institute of Technology, coöperative courses, 564, 1106
  chemical engineering, 564, 570
  establishment of, 814, 816
  merger with Harvard, 1086
Mathematics, aptitude tests, 699–738
  in curricula, 535 (graph)
  for entrance, 450
  for graduation, 461, 472, 487, 501, 514
  preparation in (France), 828
Mathematics and mechanics, 906
Maw, H. W., Editor, 775, 790–791
Maxwell, Clerk, 789
May, Mark A., 723
''Mechanics Arts,'' schools of, 817
Mechanical Engineering, curricula in, nature of, 674
    trends in, 529

  curricula, European, 928, 933, 971–974, 986
  engineers consulted, 673–680
  entrance requirements, 434, 435, 446–453
  first course in America, 815
  graduation requirements, xxvi, 434, 435, 481–494
    specific subjects, 487–494
  management, training in, 676
  national certificates, British, 928
  relations to profession, 678
  shop practice, instruction in, 677
  specialization, 674
Mechanical Engineers, Institution of, 945
Mechanical schools (German), 985, 989
Mechanical science at Cambridge, 789
Mechanics and Mathematics, 906
Mechanics' Institute (English), 778
Metallurgy (Wolverhampton), 931
Michigan, report of guidance, 178
Miller, H. W., 722
Mine foremen, school for (Alais), 869
Mines, School of (British), 785
Mining, schools of (Germany), 953, 993
Mining Engineering (mineral technology), curricula in, 682, 685
    nature of, 681
    trends in, 528
  engineers consulted, 680–687
  entrance requirements, 432, 433, 446–453
  graduation requirements, 432, 433, 469–480
    specific subjects, 473–480
  relations with profession, 686
Missions, educational, 791
Modern foreign languages, 407, 420
Monge, work of, 761, 762
Morin, General, 764
Morrill Land Grant Act of 1862, 541, 546, 815, 817, 1001, 1043
Morris at Cornell, 818
Mosely mission to America, 791
Motivation in unified program, 130, 1073
Mulhouse, schools at, 869
''Multiple-response'' questions, 695
Munich, *hochschule* at, 800
  museum at, 999
Museum, France, 763
  Germany, 999

Nancy, institutes at, 835, 848, 865–867
Napoleon and education, 764, 765
National diplomas (British), 928
National Educational System in France, 824–825
National engineering societies, see Engineering Societies
National Industrial Conference Board, 9, 1016, 1063, 1244
National system of education in America, 142, 1000, 1255
  in Great Britain, 881
Nebenius at Karlsruhe, 796
Newcastle, Armstrong College, 789
New York University coöperative courses, 578
New York, University of the State of, 1159, 1162
Nineteen-thirty Survey of Engineering Education, 1163
Non-collegiate schools, see Technical Institutes.
Non-degree courses, credentials for (British), 924, 925
Non-graduating student, 99–101
  coöperative courses, 612
Non-graduate former students, xx, xlv, 226–271
  data on, 246, 270, 271
Non-engineering subjects, teachers of related, 291, 1271
Northampton Polytechnic, 892, 918
Norton, John P. at Yale, 815
Nuremberg, school of, 800

''Objective'' questions, 694
Oberrealschulen, rise of, 794
Occupations of graduates, 228, 256, 1016
  of electrical graduates, 370–378
  relationship of, to college courses, 229–231, 257–258, 1022
Ollivier, 765
Orientation of students, 183–187, 1171
  to industry, 608
Outside work by teachers, 286, 303, 317
  name of institution, 287, 317
  use of laboratories for, 287, 317
Owens College, Manchester, 787

Oxford, technical education at, 789
Oxford and Cambridge Universities, cost and fees at, 904
  organization of, 895
  school of engineering at, 896
Paper technology at Grenoble, 869
Parents of students, 162–165, 188–189
Part-time day courses (British), 933–935
Peclet, 765
Pender, Harold, chairman, vi, 319, 340
Perronnet, father of engineeering education, 758
Personnel, engineering teaching, Bulletin 4, xxi, xlv, 272–317
  committee on, 273
    conclusions of, 289
  recruitment and losses in, 274–276, 294, 305, 306
    modes of, 105
  research, 156
  teaching, 69, 105–108, 156, 1245
  see Teachers
Personnel, student, 23–28, 65, 1241
Personnel for state service (France), 849
Personnel work in sectioning of classes, 707, 708
Petit, Dean, 865
Philosophy of Engineering Education, 1044
Physical and military training, graduation requirements in, 464, 476, 590, 504, 517
Physical science, for entrance, 451
  graduation requirements in, 462, 474, 488, 502, 515
  in curricula, 535 (graph)
Physics, aptitude tests, 702, 731, 734, 736, 739
Pickering at Massachusetts Institute of Technology, 819
Pittsburgh, University of, 1106
Placement Examinations, a study of, Bulletin 15, xxxi, lii, 688–747
  aptitude and training tests, lii, 727–741
  bibliography, 741–747
  description of, 693
  intelligence tests, prediction by, 700–707, 735
  range of scores, 736–739
  results, summaries of, lii, 727–741
Placement in industry, 235, 262–264
  of seniors, methods, 1212
    records, 1212
Plant, investment in, 345–355
Playfair, 787
Polytechnic school, Philadelphia project for a (1826), 811
  at Prague (1806), 795
  at Vienna (1815), 795
Polytechnic schools (German), 954
Polytechnics, London, 780
Popular technical education, beginnings of, 777
Positions, see Graduates
Post-graduate work, see Graduate work
Post-scholastic education, 75, 85, 117, 243–246, 252–255
  director's report, 1069, 1105, 1106, 1113
  reports of study done, 269, 384–387
Practical and school training, 155
  in British education, 892
Practice, professional, by teachers, 285, 286, 303
  See Outside work
Prague, school at, 795
Pre-engineering courses, 59, 186
Prediction, see Placement Examinations
Preparatory education, see Secondary Education
''Problems courses,'' 186
Production, training for, 1065
Profession, social function of a, 1044
  certification into, 1114
  codes, 1109
Professional discipline vs. liberal education, 1072
Professional examinations by engineering societies (British), 943
Professional life, group, 1108
  individual, 1107
Professional phase of engineering education, 1102–1114
Professional societies, see Engineering Societies.
Professors, see Teachers
Professors, in Germany, 958–959
Project-teaching (European), 845, 962–963
Public support of technical education and research, 157

Publications, lists of, 1278
  responsibility for, lxi
Pupilage (British), 773–777

Quantity production in education, 1002

Rankine, 776, 785, 787
Realgymnasium (Germany), 950
Realschule certificate, 797, 798
Recognition of colleges, see Accrediting
Remmers, H. A., 709, 744
Rensselaer Polytechnic Institute, 812, 813
  curriculum (1849), 766, 813
Rensselaer School at Troy (1824), 810, 811
Report of the Board, Preliminary, November 1926, 82
  Second Report, June 1927, 120
  Third Report, June 1929, 142
Report of Chairman, June 1930, 1
  Final Report, June 1934, 1237
Report of Director, Preliminary, June 1926, 52
  Engineering Education in United States and Europe, 1929, 748
  Final Report, June 1933, 1041
Report of Associate Director, A Summary of Fact-gathering Stages, June 1926, 17
Report of Director of Summer Schools, 1927–1933, 1117
Reports of or to the Board, see Publications of the Board and Bibliography, preceding this index
Research, American and European, 1008
  in engineering colleges, 31, 821, 1098
  expenditures for, 322
  industrial, 1051
  limitations of data on, 321
  organized engineering, 320–322, 328–332
  personnel, 156
  professional (Germany), 801
  public support of, 157
  scientific, 792, 801, 821
  summary of situation, 322
  time devoted to, 284, 311
  1930 Survey, 1208
Reutlingen, textile school of, 994
Riggs, H. E., Chairman, vi, 1039
Robert Gordon College, 790, 884
Roche, General, 770
Rochefoucauld, Duc de, school of, 764
Rogers, William Barton, 816, 818
Royal College of Chemistry, London, 785
Royal College of Mines, London, 910
Royal Ordnance Factories, apprentice training in, 891
Ruch, G. M., 690, 744
Runkle at Massachusetts Institute of Technology, 819
Russia, industrialization of, 1055
Russian school shops, exhibit of, in 1876, 820

Sabbatical leave, 287, 301
Sackett, R. L., vi, 162, 228, 621
Salaries of graduates, see Earnings
Salaries of teachers, 29
  in British universities, 898
  compensation and tenure, 293–298
  economic status of teachers, 277–279
  in German universities, 959
  and graduates compared, 278, 310
  and supplementary earnings, 277, 307–309, 316 (inset chart)
  1930 Survey, 1208
Sandwich plan (Great Britain), 892
Saxon Industrial Academy, 954
Schneider, Herman, 616, 618, 821
Schneider, M. (*Ecole Brequet*), 873
Science and Art movement (British) the, 779
Science, industry and education (English), 772, 773, 792
  studies, 149, 1067
  training, trend toward, 820
Scott, C. F., Chairman of the Board, reports, xv, 1237, 1274
  preface to Vol. II
  opens administrative conference, 1147, 1161
  summary of results of Investigation, 1237
Scottish educational system, 883–884, 773–887
Seashore, C. E., v, vi, 6

  on placement examinations, 690, 692
  on sectioning of classes, 708, 745
Selection in the curriculum, principle of, 147–152
  of students for coöperative work, 583
  in treatment of students, 99, 153–155
Selective principle in engineering education, xviii, 145–157, 1077
Secondary education, English, 884–887
    French, 826–830
    German, 950–953
    Scottish, 887
Secondary schools, function in guidance, 173, (1930 Survey) 1170
  quality of, 168
Sectioning of classes, on the basis of ability, 720, 745
  placement examinations in, 707
  personnel work in, 707–708
  report of J. B. Tharp on, 709, 747
Sequences of studies, 131
Sheffield, University of, 788, 892
Sheffield Scientific School at Yale, 815
Shop courses, 47, 409
  opinions concerning, 410, 423, 660, 670, 677
Shop instruction, development of, 819, 820
Shop practice at Worcester Polytechnic Institute, 819
Shop school (England), 893
Shops, college, elimination of, 585
Silliman, Benjamin, at Yale, 815
Social and economic changes, effect of, 1156
Social and economic content of curricula, 90–93
Social and language studies in curricula, 534
Social orientation, 1055, 1073. 1076
Social premises of Engineering Education, 1048–1056
Social science, 452, 463, 474, 488, 502, 515
Social utility, 1050
Société des Amis de l'Ecole Centrale, 858
  des Instituts Techniques, 865
Société des Ingenieurs Civils de France, 766
Société des Ingenieurs Civils, 874
  discussion of higher technical education by, 874
Societies, see Engineering Societies
Society of Arts, 816
Solvay, Ernest, 867
South Kensington, 779, 781
Spahr, R. H., 7
Spanish training test, 702, 728, 731, 736
Specialized training of graduates, 118
Specialization in technical education, 1005, 1075
Specialization in engineering, 152, 639, 640
  chemical engineering, 660
  civil engineering, 664
  electrical engineering, 670
  mechanical engineering, 674
Specialization (France), 769, 770
"Specialization," limitations, 393
  opinions as to, 393, 415, 416
  use of the term, 392
Staffs of the Summer School for Engineering Teachers, 1126
Stage in French schools, 845
State, the, and engineering education, 1159, 1162
Steiger courses, mining schools, 993
Steinmetz, C. P., 1106
Stoddard, George D., 688, 718, 741, 744, 746
Strasbourg, school at, 869
Structural engineering (London), 933
Stuart, James, at Cambridge, 789
Students (Engineering), Bulletins and Reports concerning
  Bulletin 1, At time of entrance to college, xviii, xliii, 159–192
  Bulletin 2, Admissions and Eliminations, xix, xliii, 193–225
  Bulletin 16, European Studies, Student Life, 1011
  Report of Fact-gathering, 23–27
    of Director, 65
    of Board, 102–104, 153–155
    of Chairman, summary, 1241
  1930 Survey, 1070, 1071
Students, 25, 193–225

exceptionally gifted, work of, 102–104, 1095
guidance of, 183–188, 1170
motivation of, 130, 1073
non-graduating, 99–101
personnel of, 23, 28, 65
personnel problems of, 1152, 1161
selection in treatment of, 153–155
Studienrat, title of, 952, 995
Stuttgart, *hochschule* at, 799
hydraulic engineering at, 992
Summary of the fact-gathering stages of the investigation, xv, 17–51
of the results of the Investigation, 1237, 1268
Summer Schools for engineering teachers, 7, 13, 1046–1047
contributors to, 16, Preface
director of, 7
expenses of representatives, 1209
general report, 1927–1933 Sessions, 1117–1144, see 1260
attendance, 1121, 1128
financial support, 1128
inception of, 1119
methods, 1126
objectives, 1121
plan, 1123
programs, 1124, 1134, 1137
publications, 1129, 1143
results, 1129
sessions (1927–1933), 1121
impressions as to value of (1930 Survey), 1209
publications, see Publications of Board and Bibliography
significance of, 1046, 1047
Summer schools for teachers (British), 938
Survey of Engineering Education (1930), 1163–1236
Surveying, extent of instruction in, 666
in Prussian schools, 992
Sweet at Cornell, 818, 820
Swiss Polytechnic at Zurich, 804
Switzerland, historical development of education in, 806–807

Taylor, Frederick W., 820, 822
Teachers (Engineering Teaching Personnel) Bulletins and Reports concerning
Bulletin 4, Engineering Teaching Personnel, xxi, xlv, 272–317
Bulletin 9, Opinions of Teachers concerning Curricula, xxxviii, xlviii, 388–425
Bulletin 16, American and European Studies (British), 897, 936
(German), 952, 958, 995, 999
(comparison), 1010
Summary of Fact-gathering, 19, 28
Report of Director, 69
Reports of the Board, 105–108, 156
Final Report of Director, 1097
Final Report of Chairman, 1245
Teachers, status of in America, 1010
in Germany, industrial schools, 995
secondary schools, 952
universities, 958, 999
Teachers, assistant to younger, 288
auxiliary, 276
degrees held by, 284, 315
demands on the time of, 279–284, 310–314
general summary, 28, 1245
losses of, to practice and industry, 276, 306
opportunities for development for, 287
outside work by, see Outside Work
personal and professional development of, 299–304, 1097
practice, professional, 285, 286
qualifying period of, 303
recruitment and training of, 105, 1099, 1151, 1161
salaries, see Salaries
scholarly qualifications, 1098
selection of, 289, 1151
sources of, 274, 275, 305, 1151
training and development of, 302
types of, 1098
See Summer Schools for
Teachers (local British), 936–937
summer schools for, 938
Teaching in British universities, 897–900
compared with American, 900
in French schools, 843–846
in German universities, 957–960

Teaching, instruction in the art of, 288
  load, 279, 310, 1207
  methods, changes (1926–1930), 1196, 1202
    experiments, 1202
Teaching personnel, see Teachers, Bulletins
Teaching processes, 1006
  can they be made more effectual?, 1080
  changes suggested, 1101
Technical applications, schools for, 146
Technical Education, see Engineering Education
  in America, xl, 1000–1029
  in Central Europe (Germany), xxxix, 947–999
  in England and Scotland, xxxvi, 879–946
  in France, xxxv, 824–878
  French and American, 876
  general comparison, Europe and America, 996
  historical development, xxxii, 755–823
"Technical Education," definition, 751
  legal interpretation (British), 783
Technical Education and economic well-being, 752, 753, 1156
  economic and social program needed, 144, 754
  inadequate provision for, 143
    graph, 144
  National policy needed, 144, 1255
  social and economic ends, Europe and America, 997
Technical Institutes (non-collegiate), study of, 7, 15
  Report of Study, followed by its index, Vol. II, Part 2 (latter half of this volume)
  see Publications of Board, also Bibliography
  a needed type of education, 54–55, 113, 114, 1000
  summary, see Final Report of Chairman, 1262
Technical Institutes (France), 834–836
Technical sciences, in British universities, 789
  in German universities, 793, 794
  in France, 868
Technical studies, 150
Technicum, 953
Technische Erziehung, 955, 999
Technische hochschulen, rise of, 794–799
  prestige of, 802
"Technology," use of term, 751, 816
Tenure of teachers, 293–299
Terminology employed, 751
Textbook writing, 293
Textbooks, influence of, 1095
Textile schools (European), 869 931, 994
Tharp, James B., 709, 747
Thayer, Col. at West Point, 811
Thayer School at Dartmouth, 1086
Thompson, Sylvanus, 775, 781, 782
Thurston, R. H., 814, 818–822
Toulouse, 869
Training and aptitude tests, 727
Travaux pratiques (French), 845
"True-false" test questions, 694
Tuition and fees, 347, 352, 1170
Tutorial system, 147

Undergraduate curricula, See curricula
Undergraduate status of the engineering colleges, 57, 64, 116
Unified vs. divided process of engineering education, 34, 37, xviii, 123–133, 1070, 1071
  summary of argument, 132
Union College, 813, 1106
Unit costs in education, 355
United States, see American
  Commissioner of Education, 1154, 1162, 1163
  Office of Education, 7, 426, 523, 1163
Universities, French, character of, 834
"University of France," 826
University schools of engineering (British), xxxvii, 893–917
  growth of, xxxiii, 784–788
Upper-classmen, autonomy for, 102

Van der Beke, G. E., 747
Van Rensselaer, Stephen, 810, 815
Vaucanson collection, 763
Verein Deutscher Ingenieure, 145, 801, 802, 805, 1112
"Vertical mobility" ideal of British industry, 879, 889

Victoria University, Manchester, 787, 788
Vienna, Polytechnic school at, 795
Vignols, 787
Vocational education (France), 831
Vocational guidance, see Guidance
Volkschule, 794, 949
von Gerstner, Count, plan for school at Prague (1801), 795

Warren, C. H., Chairman, vi, 273
Watt, James, 778
West Point Military Academy, 811
White, Andrew D., 817, 820
White Committee report (British), 889, 941
Wheatstone, 787
Wickenden, W. E., Director of Investigations, v, 6, 1239
  Comparative Study of Engineering Education, 748–1015
  preliminary report of, June, 1926, 52–81
  final report of, June, 1933, 1041–1116
  Engineering Education in the Light of changed conditions, July, 1933, 1156, 1162
  See Bibliography, 1922–1933
  See Technical Institutes
Winterthur, Switzerland, 950
Wood, DeVolson, 813
Wolverhampton Technical College, 930
Woolwich Polytechnic, 933
Worcester Polytechnic Institute, coöperative courses at, 564
  shop practice at, 819–820
Work, coöperative, orientation to industry, 608
  relationship to college courses, of fields of, 589
Work by students before admission, 189
Workshop production course at Wolverhampton, 930
Workshops at Cambridge, 789

Yale University, 815
Yorkshire College of Leeds, 788

Zook, George F., 1154, 1162
Zurich, Polytechnic at, 804, 807

PART 2

A STUDY OF TECHNICAL INSTITUTES

1928 - 1929

This Report in Pamphlet Form was published in 1931. A Summary Report of 40 pages was issued also and widely distributed.

An Index has been added.

A condensed summary will be found in Part 1, pages 1262 to 1268.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

BOARD OF INVESTIGATION AND COORDINATION

Charles F. Scott, *Chairman*
Frederic L. Bishop, *Secretary*
Dugald C. Jackson
Dexter S. Kimball
Robert L. Sackett
Frederick E. Turneaure
H. S. Boardman

STAFF OF THE STUDY

William E. Wickenden, *Director*
Robert H. Spahr, *In charge, Study of Industrial Requirements*
John T. Morris, *Field Representative*

ADVISORY COMMITTEE, STUDY OF TECHNICAL INSTITUTES

Frederick B. Pratt, *Chairman,* President, Board of Trustees, Pratt Institute.

Magnus W. Alexander, President, National Industrial Conference Board.

Charles R. Allen, Educational Consultant, Federal Board for Vocational Education.

Carl S. Coler, President, Westinghouse Technical Night School.

Wilmer A. DeHuff, Principal, Baltimore Polytechnic Institute.

S. S. Edmands, Director, School of Science and Technology, Pratt Institute.

John T. Faig, President, Ohio Mechanics Institute.

Dugald C. Jackson, In Charge of Department of Electrical Engineering, Massachusetts Institute of Technology.

Arthur C. Jewett, Director, College of Industries, Carnegie Institute of Technology.

James A. Moyer, Director, Division of University Extension, Massachusetts State Board of Education.

Robert L. Sackett, Dean, School of Engineering, Pennsylvania State College.

Albert Sobey, Director, General Motors Institute of Technology.

Arthur L. Williston, Former Principal, Wentworth Institute.

Copies of the publications of the Board of Investigation and Coordination may be obtained from

THE LANCASTER PRESS, INC.
Prince and Lemon Streets, Lancaster, Pennsylvania.

A STUDY OF
TECHNICAL INSTITUTES

A COLLATERAL PROJECT
OF THE
INVESTIGATION OF ENGINEERING EDUCATION

THE SOCIETY FOR THE PROMOTION OF
ENGINEERING EDUCATION

FEBRUARY, 1931

LANCASTER PRESS, INC., LANCASTER, PA.

FOREWORD

This study was conducted under the auspices of the Society for the Promotion of Engineering Education as a collateral project to its extended investigation of engineering education, and under the general direction of its Board of Investigation and Coordination. Funds were provided through the generosity of the Carnegie Corporation of New York and by a group of individuals and institutions directly interested in the field of the study.

An advisory committee, representing the technical institutes and other interests affected by the study, assisted the Staff in formulating the scope and objectives, and in reviewing the general findings and conclusions. Acknowledgment is also made of the generous cooperation of the technical institutes and their alumni, of numerous industrial concerns and trade associations, and of many public officials, officers of engineering societies and directors of schools in European countries visited in the course of the study.

Owing to the illness of Dr. John T. Morris, Field Representative, which greatly curtailed the study of the American institutions on their own ground, this feature of the study is less fully treated than its importance would merit. The text of Chapters I, II, III, VII and and VIII was written by Mr. Wickenden and that of Chapters IV, V and VI by Mr. Spahr. The Staff is indebted to Mr. C. A. Brown, Head of the Department of English, General Motors Institute of Technology, for editorial assistance in the preparation of Chapters IV, V and VI.

A STUDY OF TECHNICAL INSTITUTES

A COLLATERAL PROJECT
TO THE
INVESTIGATION OF ENGINEERING EDUCATION

TABLE OF CONTENTS

Detailed Table of Contents ....(vii)
I. Introduction and Summary of Conclusions 1
II. The Technical Institute—Its Special Character and Functions 16
III. Historical Development and Present Status of Technical Institutes in the United States 28
IV. A Study of the Technical Training Needs of Industry 48
V. A Study of Technical Institute Graduates 88
VI. Typical Studies of Occupational Responsibilities as an Aid in Curriculum Building 124
VII. The Technical Institute as a Going Concern 137
VIII. Technical Institutes of Europe 199
Index 272

Copyright, 1931
by
The Society for the Promotion of Engineering Education
(Contents may be quoted with reference to their source)

DETAILED TABLE OF CONTENTS

PART I. INTRODUCTION AND SUMMARY OF CONCLUSIONS

Principal conclusions 1
Occasion for the study 1
Gaps in American technical education 2
Technical accessions needed by industry 3
Nomenclature 3
Scope and objects of the study 4
Summary of principal findings and conclusions 6
Industry understaffed 6
Expansion of technical education needed 7
Relative outlets for college and technical institute graduates 7
Fields for which technical institute graduates are especially adapted 8
Types of men served by technical institutes 8
Local expansion of technical education 9
Distinctive field and status of technical institutes 9
Mixed junior college not a substitute 9
Day, evening and correspondence instruction 10
Cooperative plan in technical institutes 10
Geographical field for technical institutes 11
Number of technical institutes needed 11
Functions of endowed, proprietary, civic and state institutes 12
Technological, engineering and functional courses 13
Present lack of solidarity among technical institutes 14
Lack of recognized credentials a handicap 14

PART II. THE TECHNICAL INSTITUTE—ITS SPECIAL CHARACTER AND FUNCTIONS

Reasons for choosing the term ''Technical Institute'' 16
Characteristics of the technical institute 17
Relation to secondary education 18
Relation to vocational education 19
Relation to the junior college 20
Relation to colleges and universities 21
The technical institute as a school of engineering 22
Training in the technology of specific industries 24
Training for specific technical functions 25
The principle at issue 26

PART III. HISTORICAL DEVELOPMENT AND PRESENT STATUS OF TECHNICAL INSTITUTES IN THE UNITED STATES

Significance of historical influence 28
British and American experience contrasted 28
The Mechanics' Institutes 30
The first technical institute 31
The Rensselaer School 32
Development of the early engineering colleges 33
Agitation for training in industrial professions 34
Expansion of technical education at the college level 35
Shifting of technical schools into the college group 37
Successful technical institutes 38
Present status of the technical institute 39
Full-time day courses 40
Cooperative half-time day courses 42
Evening courses 43
Correspondence courses 45
Geographic area now served 45

PART IV. A STUDY OF THE TECHNICAL TRAINING NEEDS OF INDUSTRY

Characteristics and phases to be studied 48
Instruction by doing 48
Definite and desired objectives 49

A. The Experiences of the Technical Institutes

No difficulty in placing graduates 50
In close contact with industry 50
Cooperative students appear in demand 51
Graduates of some institutes in greater demand than others 51
Demand exceeds supply 51

B. Needs of Business and Industry

New Jersey selected for study of industrial requirements 52
Ratio of technical institute men to four-year college men preferred by New Jersey industrial concerns 53
Data gathered by the College of Engineering, Rutgers University .. 53
Needs of public utilities companies in New Jersey (not including communication) 57
Corroborating data from California 59
An analysis of technical training needs of an engineering and construction company 60

Countrywide industries asked for experiences 61
Relative value of general and specialized courses 63

C. Needs Based on Study of Industrial Employments

A study of five manufacturing industries 64
Percentages of technical and supervisory positions filled by college-trained men 64
Distribution of college-trained men in manufacturing by functions 66
Trained men in production 66
Technically trained college men predominate in production 67
Reasons for absence of college men in production 68
Technical institute graduates in production 69

D. Potential Fields for the Employment of Technical Institute Graduates and Extent to which Needs are Being Met

Industries and businesses now employing technical institute graduates 71
Distribution of persons gainfully employed in the United States .. 73
Potential fields estimated from U. S. Census data 74
Agriculture, forestry, and animal husbandry 74
Extraction of minerals 74
Potential needs of the mineral industries 76
Communication and transportation 77
Trade 78
Public service 78
Professional service 79
Domestic and personal service 79
Clerical occupations 79
Manufacturing and mechanical industries 80
Examples of local fields needing development 81
Manufacturing in the Philadelphia area 82
Northern New Jersey textile area 83
Present and desired status of trained men in employment 85
Estimated total potential demand for technical institute graduates . 87

PART V. A STUDY OF TECHNICAL INSTITUTE GRADUATES

Groups chosen 88
Definite objectives 88

A. Controlling Influences and Personal Reactions of Graduates

Circumstances which led up to attending these institutes 91
Personal influences 93

Limited time and means for training 93
Advertising and solicitation 94
Participation in student activities 95
Paying way through school 95
Choice of first position after institute 97
Extent to which course has met expectations of graduates 98
Need or desire for further courses of study 99
Possible means of continuation education 100
Admission to colleges with advanced standing 102
Reasons for needing further courses 104
How they attempted to meet needs for further courses 104
Modifications suggested by graduates 105
Would the graduates do it over again? 106
The effect of the absence of a college degree 108
Employability and recognition of graduates 109

B. The Status of These Graduates in Business and Industry

Types of positions held 109
Example of one-year engineering course graduates 110
Example of three-year textile course graduates 111
Example of two-year engineering course graduates 112
Earnings of graduates 113
Occupations as related to course pursued in institute 115
Paths of progression in employment 115
Shifting of graduates in employment 118
What employers think these graduates can best do 120
How well do these graduates actually function in industry? 121

PART VI. TYPICAL STUDIES OF OCCUPATIONAL RESPONSIBILITIES AS AN AID IN CURRICULUM BUILDING

The curriculum—an important problem of the institutes 124
No clearing house available for information and data 125
Aids in curriculum building 126
Analyses of typical positions in industry 127
Responsibilities measured by sum of ratings 128
Responsibilities measured by frequency of occurrence 129
Will knowing responsibilities aid in curriculum development? 130
Responsibilities of the foreman's position 131
Supervisors and draftsmen contrasted 132
Summary of observation on the use of occupational responsibilities in developing or revising curricula 133
Order of importance of foremen's responsibilities 134
Clarifying objectives of institute curricula 136

PART VII. THE TECHNICAL INSTITUTE AS A GOING CONCERN

A. General Conspectus

Summary of salient points 137–8–9
Bliss Electrical School 137
Bradley Polytechnic Institute 137
Chicago Technical College 140
Cleveland Y. M. C. A. Junior Engineering College 140
Dunwoodie Industrial Institute 140
International Correspondence Schools 141
Lowell Institute Evening School 141
Lowell Textile Institute 142
Milwaukee School of Engineering 142
New Bedford Textile School 142
Ohio Mechanics Institute 142
Pratt Institute 143
Rhode Island School of Design 143
Rochester Athenaeum and Mechanics Institute 143
Rutgers University and Pennsylvania State College, Extension Divisions 143
Richmond (Va.) Mechanics Institute 144
Wentworth Institute 144
Westinghouse Technical Evening School 144

B. Students and Student Life

Sources of data 144
Preparatory education 145
Ages of students 146
Previous industrial experience 147
Aims of students and influences in the choice of school and course .. 147
Self-support 148
Student life and activities 149
General observation 150

C. Teachers

Educational qualifications 150
Age and experience 151
Sources of recruitment 152
Qualifications most emphasized 153
Turnover of teachers 154
Salaries 155
Supplementary earnings 155

Non-teaching salaries of part-time teachers 156
Professional standing and activities of teachers 157

D. METHODS AND MATERIALS OF TEACHING

General observations 157
Selection of materials 158
Methods of teaching 159
Standards and grading 160
Dropping out of students 161
Graduation ratios 162

E. TEACHING LOADS AND WORKING SCHEDULES

Teaching loads 163
Proportion of work done under supervision 164
Scheduled hours of students' work 164

F. CURRICULA

Group 1. Day Courses in Industrial Technology

New Bedford Textile School, general cotton manufacturing 166
Ohio Mechanics Institute, cooperative power laundry course 167
American Institute of Laundering, course in laundering 168
Wentworth Institute, power plant practice 170
Wentworth Institute, foundry management and operation 170
Chicago Technical College, building construction 171

Group 2. Day Courses in Engineering

Chicago Technical College, civil and structural engineering 172
Pratt Institute, industrial mechanical engineering 174
Pratt Institute, industrial electrical engineering 175
Bliss Electrical School, electrical engineering 176

Group 3. Evenng Courses

Newark Technical School, evening electrical course 177
Drexel Institute, evening electrical course 178
Pennsylvania State College, Extension Division, evening mechanical course 178

Group 4. Miscellaneous

Division of University Extension, State of Massachusetts, course in electrical engineering 180
Flint Junior College, curriculum in engineering 181

G. COOPERATIVE HALF-TIME PLANS

Nature and origin 182
Present use in technical institutes 183
Experience of the engineering colleges 183
Financial aspects 184
Does it reduce plant and teaching burdens? 184
Coordination of scholastic and industrial phases 185
Possibilities in technical institutes 186

H. FEES AND COSTS

Fees 187
Operating costs 188
Outlook for self-financing institutions 188

I. INFLUENCES OF EMPLOYERS AND ALUMNI

Placement activities 189
Influence of employers 189
Example of organized local cooperation, Rochester, N. Y. 190
Attitude of employers on the degree issue 192
Influence of alumni 192
Alumni attitude toward further education 194

J. OPINIONS OF ADMINISTRATIVE HEADS AS TO THE FURTHER DEVELOPMENT OF TECHNICAL INSTITUTES

Value as testimony 194
Changes which might add to effectiveness 194
Should the number of technical institutes be increased? 195
Is there danger of training too many men? 195
Who should sponsor similar schools? 195
Making technical institute courses the entire program of an institution 196
Time plan considered best, good, fair or undesirable 197
Sequence of one-year unit courses 198
Outstanding traits of graduates 198

PART VIII. TECHNICAL INSTITUTES OF EUROPE

A. GENERAL OBSERVATIONS AND COMPARISONS

Value of comparative studies 199
European systems carefully planned 199
Common characteristics 200

B. FRENCH HIGHER INDUSTRIAL SCHOOLS

National education 201
Place of technical schools in the French educational system 202
Conflict of ideals 203
Primary and vocational education 203
The higher industrial schools 204
The concours of admission 205

Schools of the Practical Arts

The *Ecoles Nationales d'Arts et Métiers* 205
Concours of the *Ecoles d'Arts et Métiers* 206
The three-year program of *Arts et Métiers* 207
Characteristics of the program 209
Equipment 210
Importance of the schools 210

C. THE LOCAL TECHNICAL INSTITUTIONS OF GREAT BRITAIN

Introductory résumé 212
Technical schools in the English educational system 213
Extent of full-time and part-time education 214
Education for adolescents 214
The Scottish educational system 216
Local and central technical schools 216
The junior technical school 217
Function of apprenticeship 218
Typical apprenticeship plans, electrical engineering 219
Forms of apprenticeship 220
Examples of apprentice training 220
Order of practical and scholastic training 221
The sandwich plan 221
The internal shop school 222
Local technical schools 222
Relations of local technical schools with universities 223
Types of instruction 224
Examples of the range of instruction 225
Courses given by a large institution (Huddersfield) 226
Courses given by a smaller institution (Lincoln) 227
Summary of courses (Manchester) 228
Summary of courses, L. C. C. School of Building 229
Credentials for non-degree courses 230
National certificates and diplomas 231
Certificates in technology 233
College diplomas, certificates and associateships 233

Examples of curricula 234
Technical College, Halifax, mechanical engineering 234
Borough Polytechnic Institute, London, electrical engineering for the national certificates 235
Wolverhampton Technical College, workshop production course ... 236
Wolverhampton Technical College, course in metallurgical engineering 237
Royal Technical College, Glasgow, evening course in textile manufacture 237
Royal Technical College, Glasgow, course in gas engineering 238
London C. C. School of Building, course in structural engineering .. 239
Woolwich Polytechnic, part-time day course in mechanical engineering 239
Part-time day courses 240
Fees 241
Institutions combining university and intensive technical instruction 242
Teachers and teaching 242
The summer school for teachers 244
General observations 244
Distinctive excellences of British technical education 246

D. THE HIGHER INDUSTRIAL SCHOOLS OF GERMANY

Levels of technical education 247
Technical schools in the German educational system 247
Elementary schools 248
Continuation schools 248
Types of secondary schools 249
The higher and middle industrial schools 250
The German committee for technical education 250
Functional chart, German Committee on Technical Education 251
Types of industrial schools 252
The *maschinenbauschulen* 253
Characteristics of the higher machine schools 254
The middle mechanical schools 256
Examples of curricula for *maschinenbauschulen* 257
Hamburg, mechanical section 257
Hamburg, electrical section 258
Esslingen, section for fine mechanisms 259
Essen, middle *maschinenbauschule* 260
Typical curricula of building schools 262
Curricula of Prussian *baugewerkschulen* 262
Stuttgart, curriculum in hydraulic engineering 263
The *bergschulen* 264
Examples of *bergschule* curricula 264

Bochum, curriculum for mine foremen 265
Bochum, curriculum for mine superintendents 265
A leading textile school 265
Status of teachers 266
Costs and fees 267
Appreciation 267
General observations 267

E. Other European Systems

Sweden, technical trade schools 269
Sweden, technical gymnasia 270
Switzerland 270
Swiss technicums 271
Index 272

A STUDY OF TECHNICAL INSTITUTES

I. INTRODUCTION AND SUMMARY OF CONCLUSIONS

Principal Conclusions.—A need exists in our post-secondary scheme of education for a large number of technical schools giving a more intensive and practical training than that now provided by the engineering colleges.

These schools should train principally for supervisory and technical positions in particular industries; and, to a less extent, for engineering work of a general character.

Industry, trade and technical services could absorb in an average year from 40,000 to 50,000 men so trained to good advantage.

For many young men, this training should follow a period of industrial experience and orientation.

This need should be met principally by day schools, working on a full-time or a half-time (cooperative) schedule; evening schools should also be widely provided, both under the same and separate auspices; and correspondence instruction should be provided to fill the remaining gaps.

In the light of experience a training period equal or equivalent to two school years appears to meet the largest group of individual and industrial needs.

The curriculum and teaching processes should be based to a large degree on actual analyses of industrial usage.

In the light of experience, both in America and Europe, these schools should have their own distinctive character and direction in order to achieve a permanent success.

The name "technical institute" is proposed as the most suitable inclusive term for these schools.

Occasion for the Study.—The several branches of technical education have grown up independently of each other in the United States and with little if any unifying philosophy. With the exception of the State land-grant colleges and universities and the more recent vocational schools, which owe their unity of type and purpose to the conditions imposed by the grants of aid from the Federal government, each school has grown up around some local situation or some dominating personality. The field has been open to free enterprise, and it has been nobody's business to explore the whole situation and plan comprehensively. As might be expected, certain dominant types of schools have emerged and have stamped their character on great groups of institutions, but we have created nothing which resembles the carefully conceived and articulated national systems of technical education which exist in Europe. We have had the benefit of much unhampered pioneering and have been spared much narrow regimentation, on the one hand, but on the other have permitted broad gaps to develop with little or no sense of responsibility.

This study deals with one of these gaps. The engineering college has come to be one of our strongly defined types of institutions, and at present trade and craft schools are acquiring a more typical character and standing. The technical high school is in an unstable position; a few examples tend to maintain a distinctive character, while the great majority are rapidly becoming comprehensive high schools with some added emphasis on the manual arts. The type of institution known in Great Britain as the "local technical institution," and equally that known in continental Europe as the "technical middle school" have only a few and scattered counterparts in America. These institutions are of a post-secondary type and prepare for technical pursuits, but give a briefer, more intensive and more directly practical training than the higher professional schools for engineers. Nearly all of their students have had experience in industry or are gaining it concurrently. While many of their graduates ultimately qualify for professional posts, these schools contribute more largely to the recruitment of the supervisory or "line" side of industry. The tendency in the United States has been to add this burden to the engineering college, but there are many indications on the one hand that it confuses the aims of that institution and on the other that the needs of industry in its line organizations are being met most inadequately.

On the basis of a careful study of the personnel structure of industry, the National Industrial Conference Board reports a need for upwards of 40,000 recruits for technical and supervisory positions per annum, with barely 9,000 graduates coming from the engineering colleges and probably less than 1500 from technical institutions of a post-secondary grade, as considered in this study. Meanwhile practically one million young men are entering the ranks of our employed population each year and approximately half of them select industrial fields of activity. Of this number from 2.5 to 4 per cent will eventually reach a level of responsibility corresponding to that of a commissioned officer and from 6 to 10 per cent one corresponding to that of a non-commissioned officer. The present facilities for technical education above the secondary level, providing as they do for less than 30,000 accessions each year in full-time and half-time day schools and perhaps 5,000 to 7,000 in evening schools are obviously inadequate. With these needs in view should we enlarge and multiply our engineering colleges and convert them into schools of an omnibus type, or should we meet certain specific needs by establishing more widely another type of school, the technical institute, with its own characteristic aims and programs?

It seemed highly desirable that a special study of this problem should be made, collateral to the investigation of engineering education conducted by the colleges through the Society for the Promotion of Engineering Education. Accordingly a project for such a study was formulated by the Staff of the Society and presented to the Carnegie Corporation and to Mr. Frederick B. Pratt. Funds were provided for this purpose through their generosity, supplemented by other donors.

Nomenclature.—Throughout the study the problem of nomenclature presented a persistent difficulty. Our vocabulary of technical education is distinctly meagre and vague in contrast to that abroad. Such categories as *higher, middle* and *lower*, universally used to distinguish between types of technical schools in Europe, grate on American ears and seem to connote degrees of excellence rather than distinctions of type. The term *intermediate* was open to the same objection. To a public accustomed to classify all schools under three simple heads as *primary, secondary* or *college,* the whole matter was anomalous. Some educationists insisted on including the area of the study in ''the junior college field,'' despite the fact that the most widely accepted definitions of the latter would exclude it almost entirely. There was no way out of the dilemma, apparently, but to select what seemed to be the most suitable terms and to build distinctive meanings around them.

The key term is the common designation *technical institute* for all post-secondary technical schools giving more intensive instruction than the four-year colleges. This category, as used in this report, does not include trade schools which train for manual crafts nor junior colleges which offer only the introductory half of a complete college course. The ground covered herein relates only to terminal courses, of a content equivalent to one or more full academic years and, while more purely technical than the courses of the engineering colleges, including a substantial treatment of the underlying sciences, drawing and usually some work in English and economics.

The following types of courses may be distinguished, (1) *engineering* courses which parallel the college courses in more intensive and practical form and cover one, two or three years or their equivalent; (2) *technological* courses related to specific branches of industry, such as textile manufacturing, printing, engraving, bituminous coal mining, etc., and (3) *functional* courses, preparing for particular types of activity such as quantity surveying, textile designing, power plant management, etc. Correspondence, extension and evening courses have been included, though not comprehensively, where the total content equals at least that of a full academic year.

Scope and Objects of the Study.—In general, the study deals with an area rather than a specific type of technical education. A provisional definition of scope was set up at the beginning, embracing schools and courses:

More practical in aim and more direct in method than the usual instruction of the engineering colleges;
More advanced in character than the instruction commonly given in high schools and trade schools;
Distinctly technological and industrial in content;
Shorter in duration than a college course for a degree, but not less than one school year or its equivalent in length;
Closely related to the student's present or prospective field of employment;
Comprised in a curriculum of related subjects, organized as a terminal course rather than one preparatory for more advanced courses;
Not confined exclusively to a single technical branch, but including related scientific or liberal subject matter.

The objects were likewise provisionally defined as follows:

1. To indicate in some detail the character and extent of the need for larger development and betterment of the type of education indicated above, in the light of:
    - *a.* The requirements of industry for supervisors and technicians, some of whom will advance to higher executive and engineering positions.
    - *b.* The provision which should be made for young men to whom the training offered by the engineering colleges is not available or is unsuited.
2. To indicate in some detail the extent and character of the present educational facilities of the type indicated above. The ruling point of view is that the study relates to an area of education rather than a particular type of school.

3. To indicate by what means and through what initiative the needs may be met more adequately.
4. To indicate how institutions giving this type of education and the engineering colleges may supplement each other so as to create a well-balanced system of higher technical education. Incidentally, to consider whether the types of education can be successfully combined in one school, and if so under what conditions.
5. To indicate how educational authorities, professional societies and industrial bodies may aid in establishing this type of education on a stable and adequate basis.

It was explicity understood that the study did not enter the field of higher professional education on the one hand, nor that of specific vocational education on the other; that forms of training which meet the needs of foremen, technicians and superintendents were to be kept particularly in view, without minimizing the possibilities of advancement to posts as engineers and executives of high responsibility; and that the needs to be served are often more distinctly local than is the case with the colleges. It seemed wise to avoid fixing any formal type of school or course as a norm, in view of the wide range of needs to be kept in view.

Summary of Principal Findings and Conclusions.—1. American industry in practically all of its branches, is understaffed with men of scientific and technical education. Industrial processes have become so highly specialized that the jobs in themselves, without some carefully planned sequence and a scheme of supplementary instruction, are of greatly diminished value as training. With the rapid shift toward higher standardization and automatic processes, the total force requirements tend to diminish, but there is a striking rise in the proportion of staff experts and of highly trained technicians and supervisors. Meanwhile boys of superior ability are remaining longer in school—seven times as high a proportion attend high school as thirty years ago—and restricted immigration has greatly cut down the influx of trained men from abroad. Industry must therefore look increasingly to technical schools rather than to its rank and file for its technical and supervisory personnel.

2. The situation in industry warrants a great expansion of technical education above the present level of the secondary schools. The secondary school is itself a valuable adjunct to technical education but with the present emphasis on social adjustment it can scarcely hope to give the highly directed training demanded for the planning and supervisory work of industry, nor can young men be prepared for posts of this character much below the age of 21. Past efforts to keep pace with the recruitment of industry have led to a great increase in the numbers and size of engineering colleges giving courses of higher professional training for degrees, with the result that only this one phase of technical education has been adequately provided for in the United States. To gain higher efficiency there should be a greater diversity of technical education to serve a wider variety of individual and industrial needs. To maintain but one type of school and to ask it to meet all purposes is to invite blurring of aims and compromise of standards. The need is for schools having more definite purposes and more clearly visualized aims.

3. The present group of engineering colleges, numbering close to 150 and graduating about 9000 men each year, leave many of the needs of industry unprovided for. Engineering and sales staffs are fairly well recruited from this source; production, operating and maintenance staffs most inadequately. Manufacturing industries quite consistently estimate their normal requirements of four-year engineering graduates at from 2.2 to 3.0 per cent of their total forces. In a few industries this ratio is being approached, while in others great deficits exist. Taken as a whole, this potential demand is perhaps one-third supplied. The same industries estimate the desirable quota of employes having approximately two years of training above the secondary level at from 6.0 to 8.3 per cent of their total forces. At present this potential demand is not

more than one-fiftieth supplied and an output of from 25,000 to 30,000 graduates a year from technical institutes could be absorbed to great advantage. The estimates of relative needs made by public utility and transportation companies are of the same order, and there are grounds for believing that they fairly represent the mineral industries as well.

4. Graduates of the present technical institutes have shown positive adaptability to the requirements of industry in the following order:

Supervision in operating departments
Plant operation and maintenance
Getting on with workmen
Technical services (drafting, designing, testing, inspection, etc.)
Team work with associates
Cooperation with executives
Construction and erection in the field
Accepting plant hours and conditions
Technical sales work

The three largest groups of technical institute graduates are supervisors, engineering personnel and proprietors of business, respectively. These graduates are somewhat more stable in their early employment than engineering college graduates. The median earnings of the two groups, for equal age and experience show only a moderate margin in favor of the college men. Wherever the product of the technical institutes is known, the demand greatly exceeds the supply.

5. The technical institutes appear to cater more effectively than do the engineering colleges to young men who have previously passed through a period of industrial experience and orientation, to men who have a career plan definitely mapped, to men who have passed out of a state of book-mindedness, to men whose natural learning processes center in actual doing rather than formal study and to men who for financial or other reasons cannot devote four years or more to preparation for remunerative employment.

6. There is every reason to believe that enrollments in day technical schools, both full-time and part-time, can be greatly increased. So far as the need for total economic production is concerned great numbers of young persons can readily be released for the period needed for their training. The proportion partly or wholly free from the responsibility for self-support before the age of 21 is rising steadily. The urge toward technical pursuits normally asserts itself between the ages of 16 and 19. Technical education needs to be made widely available locally if it is to attract great numbers. There would be no warrant for establishing a college of engineering in every industrial center, whereas a technical institute might thrive in most cities of 50,000 population or more.

7. To achieve permanency and success, technical institutes should have their own distinctive field and character. This is strongly indicated by experience both in America and abroad. Attempts to give the more intensive and practical forms of post-secondary technical education in auxiliary departments of standard engineering colleges have largely failed, through becoming salvage courses for failures in the longer courses. Their positive appeal to a distinct group of genuine promise has been low. Wherever its distinctive aims are not clearly visualized and tenaciously pursued, the technical institute tends to drift into the college field, often to the neglect of the very groups it was created to serve. The mixed type of technical institution has succeeded well only in Great Britain, where a powerful tradition and the strong hand of the central authorities unite to keep the non-degree courses in a dominant position.

8. There is no basis in experience for expecting the junior college of a mixed character to do the work of a technical institute successfully. The junior college is in reality an extension of secondary education and its curriculum a truncated college course. Public authorities are gradually bringing the junior colleges under regulations governing the qualifications and status of teachers similar to those which apply to high

schools. The junior college of the prevailing type seeks to blend the educational theories of the mixed high school with scholastic work of a purely college type. Terminal courses of an intensive and rigorous character may in time be developed, but it is hard to see how they can fulfill the purposes contemplated in this study in an essentially secondary environment. The technical institute needs a director and staff who are in intimate touch with industry and specially proficient in blending scientific and practical instruction rather than leadership of the ''educationist'' type.

9. The day technical institute with an evening department is the objective to be aimed at wherever possible. The full-time day school can ordinarily maintain a rate of advance from four to six times that of the evening school and the half-time school on a virtually all-year program a rate two and one-half to four times that of the evening school. In a few instances evening schools narrow these ratios considerably by careful selection of students and exceptionally intensive work. It is difficult to maintain an efficient staff for evening work, unless the school is an auxiliary to a day school or a large industrial establishment. ''Pick-up'' teaching has too serious limitations to be considered seriously unless all other resources fail. Correspondence and extension courses are highly valuable expedients where established educational facilities are deficient and for the furtherance of education at adult levels. A vast field would remain to these agencies, even though a strong technical institute should be established in every industrial center of 50,000 or more inhabitants.

10. The cooperative plan, based on alternating periods of school work and industrial employment, seems particularly well adapted to the aims and the levels of age and work of the technical institutes. The plan has marked advantages in the training of supervisors of production, operation and maintenance—men who begin in overalls and rise by a ladder which passes through foremanship to superintendance and ultimately to management. It affords the student a valid trial of aptitude and a normal orientation to industry without necessitat-

ing a break in the continuity of education. The cooperative plan eases the economic burdens on both the student and the school. It should be pointed out, however, that the cooperative plan does not obviate in any large degree the need for extensive scientific and technical equipment; in fact the demands on equipment in a technical institute are fully as intensive, if somewhat less varied, as in the engineering college.

11. The geographical field of the technical institutes is as yet distinctly regional, primarily the industrial area east of the Mississippi and north of the Ohio and Potomac rivers and secondarily the Pacific slope. There is little prospect of an early demand for schools of this character in the dominantly agricultural areas. Much of the success of the European institutes is due to their close adaptation to regionally specialized industries. Monotechnic schools in such fields as textile manufacturing and bituminous coal mining are especially dependent on environment for success.

12. The actual needs and the potential demands are beyond the resources of voluntary and private agencies, although the latter have important contributions to make to the enterprises as a whole. The needs of the country could scarcely be met by less than 250 institutes, and seem to call for the creation of a great chain of community institutions having an organic place in city and state educational systems, yet free to achieve their own distinctive character. There appears to be no necessity for limiting these institutions strictly to the type of post-secondary education with which the present study is concerned. Secondary courses, if definite in aim and rigorous in character, as well as short unit courses for men with more limited needs, could probably be included in the scope of a technical institute, provided adult ideals and standards of work remain dominant. There are, in fact, a number of technical high schools for boys which could extend their work into the post-secondary field without serious difficulty. The essential thing, however, is that the technical institute shall be a distinctive type of institution with clear-cut purposes and specialized direction, and not tinged with the comprehensiveness of the present day high school.

13. The function of the independent, endowed technical institute resembles that of the endowed college or university in many respects. It has been almost a rule in American experience that private initiative has been quicker to recognize neglected areas of education and to occupy them than public authorities. At a later stage, after the need has been advertised and examples of successful effort have gained some prominence, the public steps in and meets the larger needs. The independent schools are then able to capitalize their freedom for experimentation with curricula, teaching methods and selective standards of admission, and to strive toward ideals of special excellence rather than the largest enrollments or most inclusive service. The private proprietary institution has been able to maintain itself in this field, because of needs otherwise unprovided for, and in certain instances has rendered an admirable service to an economical cost. Doubtless there will always be a place for highly distinctive schools of this character but the future of self-financing schools is highly precarious. Welfare organizations have also entered this field, with the aim of serving men not provided for by other agencies at the level of their actual needs. As a rule these organizations have been under the necessity of making their educational activities pay their way in full, and in some cases to contribute directly and indirectly to the financing of other activities. The temptation to ''window dressing'' has been strong and the limited resources, personnel and equipment have left room for doubt as to the quality and permanence of their work, if once the public awakens to its responsibility. A number of corporation schools, which serve as means of selective recruitment and training for special types of technical personnel, largely in the electrical industries, approximate closely to the work of the technical institutes and have attained an apparently permanent status. Each of these agencies can take a valuable part in the work to be done, and help to avert an undesirable degree of standardization, but the task as a whole is so large as to demand that public authorities assume the greater share.

14. The smaller cities, presumably nearly all of less than 50,000 population, would find it impracticable in most cases to maintain municipal technical institutes. If this gap is to be filled it must be done largely by the states. State or private institutions, it would seem, should take the responsibility for training men for the more individual and decentralized occupations, such as horology, which would rarely fall in the scope of city institutions.

15. The largest field to be served by the technical institutes appears to be that of training men in the technology of particular industries rather than that of generalized engineering courses of broad aims. The former is not largely occupied by the colleges and probably rightly so, while the latter field is widely and fairly adequately covered. This estimate of relative needs, however, does not reflect upon the effectiveness of the present engineering courses of the technical institutes, some of which are of marked excellence. The engineering field, however, offers the path of least resistance, as the colleges have already given it a wide prestige and have built up teaching materials and personnel. Intensive engineering courses, however meritorious the best may be, are likely to appeal to the public as short cuts to professional training rather than on their intrinsic merits. Strong support from the engineering profession can hardly be expected, unless the aims and merits of these courses are presented with rare discrimination. Schools for specific industries are greatly needed and no question of depressing professional standards can possibly be raised. The textile school, the foundry school, the machine production school, the instrument makers' school, the building construction school, the printing and engraving school, the school of horology, the coal mining school and the leather industries school are types widely established abroad and in great need of multiplication in America. These industries require relatively few men with a four-year professional training, but could use great numbers who have had two years or more of training adapted to their specific needs. Schools of this character could base their programs to advantage on

definite studies of usage, as determined by job analyses and specifications, in the respective industries.

16. A lack of solidarity among the existing technical institutes has doubtless been a major factor in holding back the adequate development of similar schools over the country at large. Each institution has grown up around some local situation or some individual's vision, but with little little sense of aims in common with other schools. Their heads have wisely sought to preserve this individuality and not fall into ways of standardization after the example of the colleges. The result has been an emphasis on points of dissimilarity, amounting at times to a spirit of mutual aloofness. Thus separated, the technical institutes have been unable to create and maintain a recognized status of their own. They were too often known as non-this or non-that to impress themselves on the consciousness of the country, much less its imagination. Their faculties suffered from a sense of professional isolation. There was no forum for their common problems and no organization for a united initiative. Some means of closer association seems greatly needed. Whether it should be a distinct division of the Society for the Promotion of Engineering Education or an independent body is not clear. In either case the initiative should come from the directors and teachers of the technical institutes themselves.

17. The technical institutes have been handicapped by the fact that their graduates received no educational credentials which are nationally recognized. The temptation has been strong to become colleges and award degrees. The British educational authorities and professional societies have met a similar problem most effectually through the establishment of National Certificates, National Diplomas, and Certificates in Technology awarded by central bodies.* Credentials of this character exercise an undoubted standardizing influence which might be detrimental in certain respects and advantageous in others. In any case, we have no central body of high standing which is concerned with technical education as a whole. If

---

* See pages 230–233 inc.

the several national engineering societies were to assume responsibility, the result might be to bias the development of technical institute courses unduly toward the engineering side, rather than the industrial and functional sides where the needs are greatest. The matter must remain inconclusive until the representatives of the technical institutes are themselves prepared to take the initiative.

II. THE TECHNICAL INSTITUTE—ITS SPECIAL CHARACTER AND FUNCTIONS

Reasons for Choosing the Term "Technical Institute."—It would be a difficult and perhaps thankless task to compile a glossary of terms as applied to technical education in the United States. No standard authorities are recognized and loose usage, based on loose conceptions, is tolerated good naturedly. This attitude rests in part on distrust of standardization and in part on faith in educational adventure. The engineering colleges have acquired through imitation and personal association a fairly uniform terminology. The Federal government, in its administration of the Smith-Hughes Act, is imposing a uniform terminology on the vocational schools. Outside these areas a sort of anarchy prevails, with every man making his own standards. In the pursuit of this study the Staff would have preferred to keep the emphasis on an area of education rather than a type of institution. This area, however, is but meagerly occupied over most of the country, and its boundaries are defined chiefly by what is omitted. Any such negative definitions as "non-trade," "non-vocational," "non-professional" or "non-college" education were wholly unsatisfactory. What was desired was a positive impression, of attractive possibilities, rather than a notion of gaps and omissions. In the end no alternative was found to choosing the best available positive term, which might include a variety of schools and programs, and seeking to invest it with a fairly clear-cut significance.

The term "technical institute" seems best to meet this need. Many of the best examples bear the name Institute, *e.g.,* Pratt, Wentworth, and the Rochester and Ohio Mechanics Institutes. The British schools of kindred character are known collectively as "technical institutions." The term chosen can easily be kept distinct from the term "engineering college"; it bears no suggestion of rank or grade which might be mistaken as a mark of inferior excellence. Since no recognized definition exists, the Staff has been able only to invest the term with such qualities as are found in the actual schools existing in the United States and their counterparts abroad.

Characteristics of the Technical Institute.—Broadly considered, the characteristics of a technical institute may be summarized as follows:

1. It is a school of post-secondary character, but distinct in character from a college or university in the American sense of those terms. (European usage of the term "university" is far stricter than our own; that of the term "college" much more elastic.)
2. Its purpose is to train men and women for callings and functions which occupy an area between the skilled crafts and the highly scientific professions. A fair proportion of those trained advance in time to a professional status.
3. It caters principally to persons who, either through previous or collateral experience in industry, have found their bearings and desire intensive preparation for chosen lines of progress.
4. It offers training for both technical pursuits, concerned with planning and control, and supervisory pursuits concerned with operation and maintenance. The engineering college more largely emphasizes the former, the technical institute the latter group.
5. Being intensive in purpose, its courses are of shorter duration than those of the professional colleges. They are essentially terminal rather than preparatory courses, though in some cases they are organized in successive units or stages.
6. Being a school without academic standardization, its admission and graduation requirements are less formal than those of the colleges and stress capacity and experience more than credit units.
7. Its methods of teaching are relatively direct, with a strong emphasis on doing as distinct from book study; ordinarily a high proportion of the work is done on school premises.

8. Its teachers, while possessing adequate scholarly preparation, are chosen primarily on the basis of practical experience, personal sagacity, and ability to teach through programs of orderly experience.

9. Its entire scheme of instruction follows much more closely the actual usage of industry than that of professional engineering schools.

As the courses of the technical institutes have no uniform standard of length, a somewhat arbitrary criterion was chosen for the purposes of this study which included only those offering the equivalent of at least one full academic year of post-secondary work.

Relation to Secondary Education.—The term "post-secondary" merits further discussion, implying as it does, the distinction between the technical institute and the secondary school and the relations between the two. A commission of the National Educational Association published in 1918 a bulletin on "Cardinal Principles of Secondary Education" in which the central objectives are stated to be: (1) Health; (2) Command of fundamental processes; (3) Worthy home membership; (4) Vocation; (5) Citizenship; (6) Worthy use of leisure; (7) Ethical character. A committee of the Division of Superintendence in 1928 restated the aims of secondary education as follows:

> "Education in a democracy, both within and without the school, should develop in each individual the knowledge, interests, ideals, habits, and powers whereby he will find his place and use that place to shape both himself and society towards ever nobler ends."

The committee further defined the general objectives of all education as follows:

> "1. To promote the development of an understanding and adequate evaluation of self.
>
> "2. To promote the development of an understanding and appreciation of the world of nature.
>
> "3. To promote the development of an understanding and an appreciation of organized society.
>
> "4. To promote the development of an appreciation of the force of law and of love that is operating universally."

While there is nothing incompatible between these aims and the characteristics of the technical institute as stated above, the latter clearly belongs to a later stage of education of more specific and mature aims. Two points of reference now seem well established, viz., that secondary education will become a fairly universal heritage for our normally endowed youth (75 per cent of the age group from 14 to 18 inclusive are already enrolled in California and nearly 60 per cent in the country at large) ; and that its dominant aims will be exploratory and appreciative and concerned with social adjustment and assimilation rather than highly directed vocational training. Elementary technical studies and some specific vocational courses will doubtless be included in the program, for a minor fraction of the students at least, and will serve as aids to self-discovery and a useful foundation for careers in industry and business. There is little to indicate, however, that these studies will have that definiteness and intensity that leads to assured mastery of scientific tools and analytical processes. No such condition has obtained in the past and the present tendency is away from it.

The whole spirit of the modern comprehensive high school runs against intensive, purposive study before the age of 18. Regulations governing the qualifications of teachers and principals place increasing emphasis on formal training in education and operate adversely to men qualified by experience for the type of work undertaken by a technical institute. A few distinctly technical high schools exist, chiefly in the largest cities. Most of them give vocational courses of the trade type, teach elementary drafting and shop work and prepare boys for engineering colleges. A number of them have equipment and a few of them personnel which would enable them to do work similar to that of a technical institute in a post-graduate department. The most serious drawback to their entering this field is intangible—the difficulty in creating an adult attitude toward work in the midst of an overwhelmingly juvenile environment.

Relation to Vocational Education.—The operation of the

Smith-Hughes Act, under which the Federal government extends financial aid to the States in support of vocational education, will in time modify and supplement the present scheme of secondary education on the vocational side. The law expressly limits the grants to instruction at the secondary age level by the words ''that such education shall be of less than college grade and shall be designed to meet the needs of persons over fourteen years of age who are preparing for a trade or industrial pursuit or who have entered upon the work of a trade or industrial pursuit.'' With the growth of vocational education at the trade level, it will become increasingly important to provide continuative education at a higher level. The colleges will not, and probably should not, assume this responsibility. A more flexible type of institution more directly related to industry and teaching in a less academic fashion will be needed for this purpose. The technical institute could fill this need admirably, where the college would be a misfit. The same holds for much of the higher apprentice training in industry.

Relation to the Junior College.—A candid comparison of the characteristics of the technical institute with the avowed aims and characteristics of the junior college should make it clear that the two have as yet only superficial elements in common. The definition formulated by the American Association of Junior Colleges leaves the way open for the organization of terminal vocational courses:

> ''The junior college is an institution offering two years of instruction of strictly collegiate grade. The curriclulum may include those courses usually offered in the first two years of the four-year college, in which case these courses must be identical in scope and thoroughness with the corresponding courses of the standard four-year college. The junior college may, and is likely to, develop a different type of curriculum suited to the larger and ever-changing civic, social, religious and vocational needs of the entire community in which the college is located. It is understood that in this case also the work offered shall be on a level appropriate for high-school graduates.''

The junior college, if one may judge from the institutions under public control, is frankly an extension of secondary education, usually on premises and under auspices which link it permanently to the secondary school. As yet its courses are almost exclusively truncated college courses. It is fairly vital to a junior college to be accredited by higher institutions and regional associations, a fact which permanently stamps it with an academic character. Its head and its staff are required to conform to conventional academic types. Several of the states have already adopted regulatory codes which fix the qualifications of teachers in a manner not unlike those for high school teachers, with a large quota of college credits in ''education.'' Even in so-called technical junior colleges, the only courses offered are the precise duplicates of the first two years of the university courses. One can scarcely look to such an institution to do the work outlined for a technical institute. Should it attempt it, the atmosphere would be alien in spirit. It is worthy of note that in all European countries, where the terminal levels of secondary education approximate closely to that proposed for the junior college, the higher industrial schools are kept quite distinct, with a program, calendar, personnel and regime of work adapted to their distinctive purpose. In the opinion of the Staff, little is to be expected from the American junior college of a mixed character in the area of this study, unless its aims undergo a radical change as a result of experience and evolution.

Relation to Colleges and Universities.—Many will raise the question why the work proposed for the technical institute cannot be done by a junior division, an evening school or an extension division connected with an engineering college. In the abstract, there appear to be no insuperable difficulties. The same type of equipment is needed, the staffs have many points in common and much of the teaching is of a kindred character. The practical difficulties are more serious. A college needs to protect its standing with accrediting agencies and professional societies. It wishes industry to place a definite valuation on its credentials. It must therefore maintain one standard of admission, give one level of work, and award one grade of credentials, except where special honors are added. The invariable experience in America where short and intensive courses have been offered in parallel with four-year courses for degrees is that the former have been regarded as inferior in quality and as a means of salvage for the culls of the longer course. The shorter course men have not been regarded as regular college students, or admitted to the more highly prized college organizations and activities. The effect on the morale of the shorter course men has been deadly.

Some of the German technical universities in an early phase of evolution tried the plan of making different periods of the same course serve as preparation for different pursuits. An early stage was to serve for artisans, a longer one for foremen and a still longer one for engineers and directors. The plan had to be abandoned and distinct types of schools created in order to do each task well. Some of the French provincial universities being hard pressed to secure a sufficient enrollment for their higher technical courses, maintain junior or foremen's courses partly as feeders to their advanced work. A number of British technical institutions give both intensive and university courses, but in practically all such cases the former dominate and powerful national and local controls exist to maintain this dominance.*

The most successful examples of combined functions in America are cases where the day work is strictly collegiate in character and the evening work strictly of the technical institute type. Each school may then have its own head, its own atmosphere and traditions, and in some cases its own name. The Lowell Institute School, which is conducted under a separate foundation at the Massachusette Institute of Technology, is perhaps the most notable example of such a combination. The Newark (N. J.) Technical School and Drexel Institute are also examples of note.

The Technical Institute as a School of Engineering.—As a school of engineering—using that term in a fairly strict sense—the technical institute has a distinctly useful, but relatively limited place. If the United States had half its present number of engineering colleges *—say 75 in place of 150—the sphere of the technical institute in engineering education might represent virtually half the field. Since terms are not always used or understood alike, it is well to point out the distinction which is made in the present report between courses in engineering, in the technology of specific industries and in technical functions.

---

* See pp. 223 and 242 for a fuller discussion.

Engineering courses represent the minimum degree of specialization. Within certain broad, almost generic, divisions—civil, mechanical, electrical, etc.—the aim is to teach, as fully as a fixed time will permit, the whole science of the field, with only incidental regard to any particular industry or function. Such specific practices as are taught are largely the tools of analysis and representation, and only incidental ends in themselves. Implicit in the whole process is the aim of preparing the student to choose, on scientific and economical grounds, among the whole range of resources which may be employed to solve a problem. Training of this type cannot be completed in a school, but must be rounded out by experience in order to create a sound basis for independent judgment.

It is the range of problems encountered in engineering and their predominantly original character rather than the intricacy of any special technique that determines the length of the requisite training. Certain basic sciences—mathematics, chemistry, physics and mechanics—should be covered *in extenso* and their wide ramifications in technical realms traced out in a somewhat comprehensive way. Experience has shown unmistakably that the least time in which this can be done with fair completeness and thoroughness, and with an admixture of language and social science sufficient to assure the engineer reasonable powers of expression and economic insight, is four years after the completion of a properly selected secondary course. This training, in itself, is insufficient for the more exacting analytical problems of engineering.

---

* Germany, with approximately half our population and a relatively more intensive industrial economy, has eleven polytechnic and two monotechnic *hochschulen* of university rank.

At the same time there are innumerable positions in industry for which men of engineering training are sought which do not utilize a wide range of scientific or technical knowledge. Many of these positions are conventionally classed as engineering and many open paths to high responsibilities in producing and operating organizations. The technical requirements of these posts can be fairly met by an intensive type of engineering training which avoids the most advanced scientific features and which can be given with creditable thoroughness in two or three years, or even one. In Great Britain, where engineering courses for university degrees have attracted relatively limited numbers, much the greater part of the technical recruitment of industry comes from engineering courses of this more intensive type, given in evening and part-time schools for engineering apprentices and other employed men.

Training in the Technology of Specific Industries.—Courses in the technology of specific industries involve a higher order of specialization than an engineering course, yet not necessarily a narrow training. The term *technology* signifies the generalized science of an industrial art. Printing, iron-founding, coal-mining, photo-engraving, tanning, paper-making, cotton-spinning, watch-making, die-casting, framed construction—in fact, innumerable technical pursuits—have each an underpinning of scientific knowledge and a content of rational practices from which results can be predicted with a considerable degree of accuracy. Each draws selectively on many sciences, but one need not master each of these sciences as a whole to gain proficiency in the art. One need not know all of chemistry to be an expert in paper making or all of physics to master the art of cotton spinning or weaving. Since the bounds of needful knowledge can be more accurately predetermined and subject matters introduced selectively, in unit form, and without the elaborate concatenation which marks the engineering course, industrial technology can be taught in much more intensive form than engineering.

No sharp boundaries can be drawn in this realm between vocational, industrial and professional education. One could study iron-founding as an individual trade, or as an industrial process of many branches to be supervised and coordinated, or as a part of the profession of ferrous metallurgy. In general, however, it seems apparent that the needs of industry for supervisory personnel do not fall mainly in the area of single skilled trades, nor mainly in a professional realm for which one prepares in a four-year college course or longer. The printing industry needs many compositors, stereotypers, press men and like vocational specialists. It needs a certain number of men who have been trained to view the art, technique and economics of the industry as a whole, but for the present, at least, one college giving a degree course is more than adequate to supply the whole demand. The wider experience of Europe reinforces very strongly our more limited American experience in supporting the view that craft training, however excellent, is not in itself enough to qualify men for responsible supervisory positions and, on the other hand, that courses in the technology of specific industries have a very limited place, when any, in the college or university sphere. Training for technological supervision falls naturally within the area here proposed for the technical institute and constitutes the major function of that type of institution.

In certain sections of the country where the engineering colleges are the only effective technical schools one may see the attempt to incorporate the technology of textile manufacturing into the group of engineering degree courses carried to fairly absurd lengths. There is a place for textile engineers, men who design machinery and plant for the industry, and a need for a school or two to train them, but the training of operating and supervisory personnel is quite another matter. It is a misnomer to call it ''engineering'' and doubtful wisdom to pad it out into a college-degree course.

Training for Specific Technical Functions.—This type represents a still higher order of specialization than the two already discussed. An example may be taken from the work of the quantity surveyor, whose function it is to take off from building plans complete schedules of the quantities of materials, areas, volumes, numbers of unit items, etc., from which bidders may estimate their costs with a minimum of guess work and on a strictly comparable basis. To perform this work one must have intimate knowledge not only of plans and conventions, but also of specific details of construction not represented on the plans. On the other hand, a limited knowledge of design calculations for strength and resistance, and the like, will suffice.

In setting up educational courses of this type it is entirely practicable to proceed from a detailed job analysis and one can with fair safety trim the program to strict essentials. Most of these specific functional jobs have attractive outlets to posts of responsibility, usually more executive than technical in nature. This field of education belongs by rights to the technical institute rather than the college. Comparatively few examples can be found in the United States, but courses of this character are fairly abundant in Europe, where specialization is more often looked on as an advantage. Courses for land surveyors, quantity surveyors, power plant superintendents, mine equipment foremen and the like are to be found in Great Britain, France, Germany, Switzerland and elsewhere on a fairly wide scale.

The Principle at Issue.—The actual issue between the college and the technical institute narrows down to a choice between using the by-products of a training for professional service to supply a much larger quota of recruitment for industrial supervision or, on the other hand, providing a distinctive training for these non-professional or semi-professional functions. Admittedly, a considerable part of the present demand on the engineering colleges could be filled by technical institute graduates, and often with greater satisfaction to both parties, if an adequate supply existed. Thus relieved, the colleges could emphasize more truly professional aims and standards. From the viewpoint of industry, a thoroughly trained technician or operating supervisor ought to be more acceptable than a half-baked or ill-adjusted engineer.

College training and the degree have acquired an unwarranted prestige, and much of the demand on the colleges, both for admission and recruitment, is not of a discriminating character. The college would be better for closer competition, and a second educational ladder paralleling part at least of its range but more flexible in its entrance and terminal levels would make for greater democracy of educational opportunity. Engineering colleges, if loyal to their professional aims, ought to admit graduates of vocational courses only in exceptional cases. Nor can the college best serve many men who have had considerable experience in industry and wish to make intensive preparation for progress along quite specific lines. Such men, as a rule, are no longer book-minded. Their attitude is not that of the ''student'' so much as that of the ''learner,'' progressing through experience rather than the lore of books. A school which teaches largely by doing enables such a man to pass rapidly through a selective program of educative experiences such as he may seldom acquire in a long course of ordinary employment.

If democracy is the principle at issue, let us have more than one type of school, for more than one type of man. If efficiency is the issue, it will be well to shun at the adult level that vague comprehensiveness of aim and the social adjustment ideal which properly belong to the secondary school. Technical education can become more effective only as its aims become more clearly defined, and a rational division of the field makes for this end.

III. HISTORICAL DEVELOPMENT AND PRESENT STATUS OF TECHNICAL INSTITUTES IN THE UNITED STATES

Significance of Historical Influence.—While the historical development of technical education in America throws but little positive light on our problems, it reveals negative influences which have affected the technical institutes profoundly, causing some to abandon their original mission in order to become engineering colleges of the prevailing type and leaving others to either an isolated or a precarious existence. The case for or against the technical institute of today does not rest largely on historical precedents or sanctions, but upon the increasing differentiation of functions in both industry and education. Whatever conditions may have prevailed in past decades, no "omnibus" type of technical education will meet contemporary needs. The historical summary which follows is intentionally sketchy, while the evidence drawn from studies of the needs of industry and the records of graduates, is set forth in the two following chapters in considerable detail.

British and American Experience Contrasted.—Beginning about 1800 a movement for the education and welfare of working men, one of the significant outgrowths of the industrial revolution, flourished for half a century with varying degrees of vitality, both in Britain and America. In Britain this movement became the main stem in the development of technical education. Passing through successive stages in working men's colleges, mechanics' institutes, grants for successful examinations in "science and art" subjects and later in "technological" subjects, educational and welfare centers (Polytechnics) established by private and public benevolence for the working population of London, the movement for the education of industrial workers has flowered in 250 or more "local technical institutions" throughout Great Britain, with a total enrollment far exceeding 100,000 men, mostly in part-time and evening classes. The university arm of technical education was much slower in development and has only recently reached a state of any numerical strength.

In its early stages the American movement closely paralleled that in Great Britain. Early in the 1820's mechanics' institutes were established in the principal cities and schools were created to aid in disseminating scientific information among farmers and mechanics. The advent of the railroad led to a period of rapid industrial development and of westward migration. At once there arose an active demand for engineers of a scientific training. As there was no established body of practitioners, the British plan of professional training by pupilage was impracticable. The one established scientific school of the period, Rensselaer, responded quickly to the need and introduced a professional course of studies patterned after the higher technical schools of France.

The new discipline was rapidly assimilated into the then developing university system, and given an immense stimulus by the Morrill Act of 1862 which led to the establishment of the land-grant colleges. In the same period other forces drew attention away from the education of industrial workers—the growth of public high schools, increased immigration bringing a stream of well-trained men from abroad, and the natural ingenuity of an intelligent people drawn from pioneer stock. Scattered efforts were made to create technical schools of a more practical and flexible type. The majority, however, were gradually drawn into the dominant type of engineering college. A few, through loyalty to the purposes of their founders or the tenacity of their directors, have evolved into the present-day technical institutes. Where the colleges have reached a high degree of conventional uniformity, the technical institutes have preserved a high degree of individuality. On the one hand, the college degree has become a powerful magnet and its attendant "credits" a great standardizing force; on the other, the lack of any distinctive credentials in common has been a drawback to the growth of the technical institutes, but has protected them from loss of individuality.

The Mechanics' Institutes.—The original roots of our technical education were in a voluntary movement of the industrial classes. In New York an apprentices' library and a school for the children of mechanics were established in 1820 by the General Society of Mechanics and Tradesmen. An apprentices' library was also established in Boston in 1820 and in 1827 a mechanics' institute was organized for "mutual instruction in the sciences as connected with the mechanic arts." The Maryland Institute of Baltimore was organized in 1825 to hold annual exhibitions of manufactures, conduct scientific lectures and maintain a library. The most famous of the mechanics' institutes of this period was the Franklin Institute of Philadelphia. The resolutions which led to its incorporation in 1824 indicate the scope and aims of these organizations:

> "Resolved, That it is expedient to form a Society for the promotion of the useful arts in Philadelphia, by extending a knowledge of mechanical science to its members and others at a cheap rate.
>
> "Resolved, That the best mode of attaining this object will be by the establishment of Popular Lectures, by the formation of a cabinet of models and minerals, and of a Library, and by offering premiums on all useful improvements in the Mechanic Arts.
>
> "Resolved, That the Society shall consist of Mechanics, Manufacturers and others friendly to the useful arts."

The Mechanics Institution of Glasgow (1823), and that of London (1824) were the models on which the Franklin Institute was patterned.

The Ohio Mechanics' Institute of Cincinnati, opened in 1828, was the only one of this early group to evolve into the type of technical institute with which this study deals. A statement of its scope and methods published in 1841 is typical of the period:

> "A course of lectures is delivered every winter, occupying two or three evenings each week, upon all branches of Natural Philosophy, in regular courses. Classes are established for the prosecution of any study, whether of the Sciences or of the

> Ancient and Modern Languages, whenever any number of young men choose to organize themselves for this purpose; and they are taught upon the principle of mutual instruction, some important teacher giving his services at the commencement to enable them to adopt the most suitable method of instruction.''

The First Technical Institute.—The pioneer honors in the organized teaching of industrial science undoubtedly belong to the Gardiner (Maine) Lyceum, established in 1822 on the initiative of a group of citizens and under the direction of Benjamin Hale, who had been a tutor at Bowdoin College. For support, it depended on fees, gifts and grants from the State legislature. When the latter were withdrawn the Lyceum faded out after a decade of successful operation. It was a significant milestone, however, pointing the way to the modern technical institutions at a time when the established institutions of learning were largely indifferent to science and blind to the economic needs about them. The principal aims at Gardiner were

> ''to give farmers and mechanics such a scientific education as would enable them to become skillful in their professions.''

The original course of study covered two years, later extended to three. As published in 1827 the program was as follows:

> ''*First Year.*—Arithmetic, Geography, Book-keeping, Algebra, Geometry, Mensuration and Linear Drawing.
>
> *Second Year.*—Trigonometry, Surveying, Navigation, applications of Algebra and Geometry. Differential and Integral Calculus, Mechanics, Perspective, Chemistry and Agricultural Chemistry. Instead of the last mentioned subject Civil Engineering is pursued by those who prefer it.
>
> *Third Year.*—Natural Philosophy, Astronomy, Political Economy, the Federalist, History, Mineralogy, Natural History, Natural Theology.''

The intensive sequence of technical studies in the first two years and the contrasting liberal quality of the third year are striking. What we now call short unit courses were also provided, one in Civil Architecture, one in Surveying, one in Navigation, one in Chemistry and a fifth in Agriculture. The first and fifth occupied four months, the others three. The methods of instruction were even more prophetic than the curriculum:

> "It is the constant object in instruction at the Lyceum to familiarize the students' minds with the practical application of their lessons. Surveying and Levelling are taught not only in the recitation room but in the field; the pupil in chemistry is carried into the laboratory and allowed to perform experiments; and the classes in Mechanics are exercised in calculating such problems as occur in the practice of the machinist or engineer. Habits are thus formed of great importance to pupil; and he becomes familiar with those processes of thought which will be necessary to him in active life. His mind is not only stored with the abstract principles of science, but he has learned the very distinct and no less difficult lesson of bringing his knowledge to bear on any subject to which it is applicable."

The Rensselaer School.—The dominant aim of these early efforts was the diffusion of scientific knowledge among farmers and artisans rather than the preparation of a highly trained body of technicians. The chief difficulty encountered, both in Britain and America, was the scarcity of effective lecturers and teachers. Stephen Van Rensselaer of Albany, a prominent land owner, capitalist and leader in public affairs, was quick to grasp the situation and prepare a remedy. In 1823 he took steps to establish a school at Troy,

> "for the purpose of instructing persons who may choose to apply themselves in the application of science to the common purposes of life. My principal object is to qualify teachers for instructing the sons and daughters of farmers and mechanics, by lectures or otherwise, in the application of experimental chemistry, philosophy, and natural history to agriculture, domestic economy, the arts and manufactures."

The genius behind this undertaking was Amos Eaton, a Williams graduate who had done advanced work in chemistry and natural science under Prof. Silliman of Yale. Van Rensselaer had employed Eaton to make certain surveys for the improvement of agriculture and had been deeply impressed by his scientific capacity and practical sagacity and by his exceptional ability to rouse popular interest in the application of science to everyday pursuits. The aim of the school was simply to train qualified teachers of science who might go out and do what Eaton himself had done.

In his plan for the school Van Rensselaer specified that:

> "In every branch of learning the student begins with its practical application and is introduced to a knowledge of elementary principles from time to time, as his progress requires. . . . By this method a strong desire to study an elementary principle is excited by bringing his labors to a point where he perceives the necessity of it and its application to a useful purpose."

Development of the Early Engineering Colleges.—Rensselaer might have remained a training school for teachers of science but for a significant turn in economic history. The coming of the steam railroad to America was almost coincident with the establishment of the School. Public works, manufacturing, mining, and urban growth were quick to feel the stimulus of mass transportation. The railroad system spread with amazing rapidity. The first steam locomotive appeared in 1829. By 1836, there were 29 railroads under construction with 1750 miles of track surveyed and nearly 400 miles actually laid. Westward migration, hitherto restricted to the waterways, began to develop on a vast scale.

At once there arose a demand for engineers versed in the science of location and construction. Except for a few military engineers trained abroad, mostly in France, the earlier group of land surveyors, builders of roads, canals and bridges, and practical constructors of machinery were largely self-taught. Many men—Washington and Jefferson among them—turned their hand on occasion to engineering pursuits, but few gave them their full attention. With no established body of practitioners at hand it was impossible to introduce the British plan of training engineers by pupilage. The engineering school arose in the gap from simple necessity. Rensselaer was quick to respond. By 1835 it had evolved a definite engineering curriculum and conferred on its first class the degree of Civil Engineer. Within fifteen years the new discipline had overshadowed the original purpose of the school, and Rensselaer was reorganized in 1849 as a Polytechnic Institute with an advanced program patterned after *Ecole Polytechnique* and *Ecole Centrale* of Paris, then the dominant technical schools of Europe.

The course of studies was soon lengthened from three years to four in order to articulate it with American secondary education. Thus, quite fortuitously, Rensselaer worked out a professional course for engineers, which virtually paralleled in its length and terminal levels the long established curriculum of the arts colleges. With the way thus prepared by circumstances and example, the assimilation of the new discipline into the newly-forming scheme of university education went forward rapidly. Union, Dartmouth, Yale, Harvard and Michigan within five years made provision for professional schools and courses in engineering and applied science. Meanwhile two circumstances had somewhat diminished the earlier demand for elementary scientific instruction. One was the influx of well trained artisans and technicians from abroad. Meanwhile the American system of secondary schools was spreading rapidly. With the growing dissemination of scientific and technical information, native ingenuity and resourcefulness, bred of pioneer experience, flowered in innumerable inventions and improvements of machines and processes.

Agitation for Training in Industrial Professions.—The economic life of the pioneer era had been comparatively unspecialized. Men prized versatility more than expertness and turned their hand on occasion to a wide variety of pursuits. With the passing of the pioneer phase there was a rising demand for experts. The agitation which led to the Morrill Act for the establishment of ''colleges of agriculture and mechanic arts,'' reflects this attitude very clearly. From the original aims in view, it might seem that schools of the technical institute type would have met the needs in a natural way. It is clear, however, that such was not the intent of those who promoted the movement. The chief spokesman, Johnathan

Turner of Illinois, had been a college professor. His philosophy is epitomized in answers to two questions which he posed in an address to the teachers of the State in 1850:

> "What Do the Industrial Classes Want? . . . They want, and they ought to have, the same facilities for understanding the true philosophy, the science and the art of their several pursuits (their life business) and of efficiently applying existing knowledge thereto, and widening its domain, which the professional classes have long enjoyed in their pursuits. . . .
>
> "2. How, Then, Can That Want Be Supplied? . . . I answer, first negatively, that this want cannot be supplied by any of the existing institutions for the professional classes, nor by an incidental appendage attached to them as a mere secondary department. . . . They need a similar system of *liberal education* for their own class and adapted to their own pursuits; to create for them an *industrial literature,* adapted to their professional wants; to raise up for them *teachers* and *lecturers* for subordinate institutes; and to elevate them, in their pursuits, and their posterity to that relative position in human society for which God designed them.
>
> "The whole history of education, both in Protestant and Catholic countries, shows that we must begin with the higher institutions, or we can never succeed with the lower; for the plain reason that neither knowledge or water will run uphill. No people ever had, or ever can have, any system of common schools and lower seminaries worth anything until they have first founded their higher institutions and fountains of knowledge from which they could draw supplies of teachers, etc., for the lower. We would begin, therefore, where all experience and common sense show that we must begin, if we would effect anything worthy of our effort."

Expansion of Technical Education at the College Level. —From 1860 on, two movements, unlike in origin and in conscious aims, worked irresistibly to this end. The East, with its accumulated wealth and strong tradition of private initiative, continued to foster the technical professions in private institutions. To those already mentioned were soon added the Massachusetts Institute of Technology, the School of Mines at Columbia, and Cornell, which together with Rensselaer and Michigan, have been perhaps the most widely influential of all our schools of applied science. The West was rich in land, but poor in money, and under the necessity of telescoping into decades a social evolution which in the East has covered two centuries and in Europe two millenniums. Hence the pressure for highly socialized education, backed by Federal aid in land grants and money.

It is not strange, under the circumstances, that this movement for technical education used the college and university as its medium of expansion. The college had arrived first in our educational structure. It had an ancient lineage; its degrees were hallmarks of the "learned professions"; and its personal associations had begun to take on prized qualities of social favor and distinction. The desire to gain these intangible advantages for the technical pursuits acted as a strong conventionalizing influence.

There were, of course, occasional enterprises of a more unique nature. The Worcester County Free Institute of Industrial Science brought together in 1868 a school and a commercial shop with aims almost identical with the present *Ecoles d'Arts et Métiers of France.* The first president, C. O. Thompson, stated the ideas behind the institute at its opening, in part as follows:

> "That all mechanical engineers will find their account, in future in going through a work-shop training.
>
> This shop-work instruction may precede, accompany or follow the intellectual training, but for many reasons preferably accompanies it.
>
> The work-shop training is best given in a genuine manufacturing machine shop where work is done that is to be sold in open market and in unprotected competition with the products of other shops.
>
> That the question who shall be a superintendent, or foreman or engineer engaged in designing or draughting machinery cannot be settled in any school—that being a question to be determined only by actual trial. . . . Hence it will follow that, while all receive the preliminary training requisite for engineering, many will not attain to it, but will find a full reward for all their time and labor in superior intelligence as workmen —in being masters and not servants of the machines they make or run."

The Institute, while retaining its commercial shop, gravitated steadily in other respects to the conventional norm of the engineering colleges, and since 1887 has been known as the Worcester Polytechnic Institute.

Shifting of Technical Schools into the College Group.—A considerable group of institutions which in their early years fulfilled in large degree the functions of technical institutes, were led by one influence or another to abandon this field to become conventional four-year engineering colleges. Among this group are included the present Polytechnic Institute of Brooklyn, first opened in 1855, but fully collegiate since 1889; Cooper Union, established as a night school in 1859 to which a Day School of Technology was added in accordance with the donor's instructions in 1900, extended its latter department to a full four-year basis in 1905; Drexel Institute of Philadelphia founded in 1891 to give training in the arts and sciences as applied to industries, was distinctly a technical institute until 1915, when its several day schools were placed on a degree-granting basis; Armour Institute of Chicago opened in 1893 with both collegiate and vocational departments, but gradually discontinued the latter and since 1901 has been exclusively a college of engineering. The Carnegie Technical Schools of Pittsburgh were originally designed to be a technical institute of outstanding character and resources. As originally constituted in 1905, it included a School of Applied Science of flexible program, a School for Apprentices and Journeymen, a School of Applied Design, and a Vocational School for Women; in 1912 the institution was reorganized as a group of degree-granting colleges, its name changed to the Carnegie Institute of Technology, and its original character retained only in its evening division. Other institutions which, in whole or in part, underwent a similar transformation were the Michigan State College, the Oregon Agricultural College, Lewis Institute and Bradley Polytechnic Institute. A considerable number of land-grant colleges have offered two-year courses in industrial arts, at one time or another, and a few continue to do so. None of these courses, however, has drawn any considerable enrollment and the effort has shown no signs of permanent success.

Considered individually, the motives at work in this transformation were natural and largely above reproach. The country had no philosophy of technical education to lend support to variants in type. The conventional colleges enjoyed prestige and their degrees conferred tangible advantages. Industries and professional societies were increasing their recognition and favors to ''established colleges of engineering.'' Pressure came from alumni ''to get on the band-wagon.'' Heads of institutions naturally craved the prestige of the college president's post. As secondary education advanced, and occupied the vocational field, less need seemed to exist in this area. Labor organizations viewed all but professional technical courses with suspicion. Employers who were ''sold'' on technically trained men in staff departments, were inclined to recruit their supervisory forces from the ranks. There were few incentives to enter or to occupy the technical institute field, except as a pure welfare service to otherwise underprivileged men, while the sources of discouragement were many.

Successful Technical Institutes.—Against this adverse tide a number of technical institutes, founded with clearly visualized aims and directed by men of tenacious pupose, have held their ground successfully. The best known is undoubtedly Pratt Institute, founded in 1877 by Charles Pratt and since administered by his family with unswerving loyalty. Mr. Pratt was a successful and practical manufacturer, interested in the welfare of the young people of Brooklyn, who undertook to provide them with the training he himself had found by experience might have been of the most service to him in his career. The Ohio Mechanics Institute of Cincinnati and the Rochester Athenaeum and Mechanics Institute have continued the early tradition of training in industrial science for the supervisory forces of industry. Wentworth Institute of Boston, founded by a bequest which specified its purposes closely, has become both a vocational school and a technical institute of high character. The Bliss Electrical School of Washington is an example of personal enterprise, notable for the fact that by prudent management it has been not only self-sustaining at a scale of charges attractive to the public, but has earned the greater part of its capital as well. Cooper Union of New York and the Newark (N. J.) Technical School, have both placed their day courses on a purely collegiate basis, but maintain vigorous technical institutes as evening departments. The Lowell Institute School, conducted at the Massachusetts Institute of Technology, is perhaps the most notable of an evening school of distinct character, conducted in the same plant as an engineering college.

All facts considered, the case for the technical institute is primarily contemporary, rather than historical. Its past evolution in America reveals the difficulties to be met and overcome in its future development, but the sanctions of its existence are in the newer conditions of our industry, with its rising specialization, in the modern problem of technological unemployment with its attendant needs for intensive reeducation of men displaced and in a social philosophy which aims to provide not uniform but varied educational opportunity of equal excellence for all men.

Present Status of The Technical Institute.—The present number and strength of the technical institutes and the range of their offerings are difficult to gauge, for lack of widely accepted definition and boundaries. A practically complete inventory within the boundaries of the present study revealed a fairly surprising amount of activity over the country, but with a striking lack of unity in organization, curricula and methods. This diversity was to be expected in view of the lack of common consciousness among the scattered institutions and the variety of local influences controlling their growth. It is fairly striking, however, that so little of the total activity within the field of observation is carried on in schools which make this type of work their primary function. The following is a summary of the institutions and courses judged to fall within the field of the study. While every effort was made to gather complete information, the list is probably not exhaustive.

FULL TIME DAY COURSES

Note: Prefixed symbols have the following significance:
*Predominantly a technical institute.
**Predominantly a degree-granting college or university.
***An industrial school of mixed character.

*BLISS ELECTRICAL SCHOOL, Washington, D. C. (Proprietary)
1-year Course in Electrical Technology

*BRADFORD-DURFEE TEXTILE SCHOOL, Fall River, Mass. (State)
3-year Course in Cotton Manufacture
2-year Course in Chemistry and Dyeing
2-year Engineering Course

**BRADLEY POLYTECHNIC INSTITUTE, Peoria, Ill. (Endowed)
2-year Course in Applied Electricity
2-year Course in Machine Drafting
2-year Course in Machine Shop Practice
Course in Horology

*CALIFORNIA POLYTECHNIC INSTITUTE, San Luis Obispo, Cal. (State)
2-year and 4-year Courses in Mechanics
2-year Course in Industrial Electricity

**CARNEGIE INSTITUTE OF TECHNOLOGY, College of Industries, Pittsburgh, Pa. (Endowed)
2-year Course in Building Construction
2-year Course in Metal Trades
2-year Course in Printing

**CHICAGO TECHNICAL COLLEGE, Chicago, Ill. (Proprietary)
2-year Course in Architectural Engineering
2-year Course in Civil and Structural Engineering
2-year Course in Contracting, Architectural Drawing and Building Construction

2-year Course in Electrical Engineering
2-year Course in Mechanical Engineering
1-year Course in Surveying, Topography and Mapping

***DUNWOODIE INDUSTRIAL INSTITUTE, Minneapolis, Minn. (Endowed)

2-year Course in Building Construction
2-year Course in Highway Construction Surveying, Drafting and Computation
2-year Course in Industrial Electricity
1-year Course in Surveying and Highway Engineering

***FRANKLIN UNION, Boston, Mass. (Endowed)

2-year Course in Industrial Chemistry
2-year Course in Industrial Electricity

***HEALD TECHNICAL SCHOOL, San Francisco, Cal. (Proprietary)

2-year Course in Electrical Engineering
2-year Course in Mechanical Engineering

**UNIVERSITY OF IDAHO, Southern Branch, Pocatello, Idaho. (State)

2-year Course in Industrial Electricity

**IOWA STATE COLLEGE, Ames, Iowa. (State)

2-year Electrical Course
2-year Mechanical Course
2-year Structural Course
2-year Highway Course

**LOWELL TEXTILE INSTITUTE, Lowell, Mass. (State)

3-year Course in Cotton Manufacturing
3-year Course in Wool Manufacturing
3-year Course in Textile Designing

**MILWAUKEE SCHOOL OF ENGINEERING, Milwaukee, Wis. (Proprietary)

2-year Course in Industrial Electrical Engineering
1-year Course in Commercial Electrical Engineering

*NEW BEDFORD TEXTILE SCHOOL, New Bedford, Mass. (State)
- 3-year Courses' in Circular Knitting, Carding and Spinning
- 2-year Courses in Cotton Manufacturing, Designing and Chemistry
- 2-year Courses, Junior Manufacturing and Mechanical

***OHIO MECHANICS INSTITUTE, Cincinnati, Ohio. (Endowed)
- 2-year Course in Industrial Electrical Engineering
- 2-year Course in Industrial Mechanical Engineering

***PHILADELPHIA TEXTILE SCHOOL, Philadelphia, Pa. (Endowed, Public Aid)
- Courses in Textile Technology

*PRATT INSTITUTE, School of Science and Technology, Brooklyn, N. Y. (Endowed)
- 2-year Course in Industrial Chemical Engineering
- 2-year Course in Industrial Electrical Engineering
- 2-year Course in Industrial Mechanical Engineering

***WENTWORTH INSTITUTE, Boston, Mass. (Endowed)
- 2-year Course in Electrical Construction
- 2-year Course in Foundry Management and Operation
- 2-year Course in Machine Construction and Tool Design
- 2-year Course in Power Plant Practice

**UNIVERSITY OF WISCONSIN, Extension Division, Milwaukee, Wis. (State)
- 2-year Course in Building Design and Construction

COOPERATIVE HALF-TIME DAY COURSES

***OHIO MECHANICS INSTITUTE, Cincinnati, Ohio. (Endowed)
- 2-year Course in Power Laundry Operation

*ROCHESTER ATHENAEUM AND MECHANICS INSTITUTE, Rochester, N. Y. (Endowed)
- 3-year Course in Construction Supervision and Architectural Drafting

3-year Chemical Course
3-year Electrical Course
3-year Mechanical Course

(*Note:* The General Motors Institute of Technology conducts four-year cooperative courses which, while not leading to degrees, are practically indentical within their limits with college courses in engineering.)

EVENING COURSES

**CLEVELAND Y. M. C. A. SCHOOL OF TECHNOLOGY, Cleveland, Ohio. (Y. M. C. A.)

3-year Course in Chemical Engineering
3-year Course in Civil and Structural Engineering
3-year Course in Electrical Engineering
3-year Course in Mechanical Engineering

**DREXEL INSTITUTE, Evening Diploma School, Philadelphia, Pa. (Endowed)

4-year Evening Course in Architecture
4-year Evening Course in Building Construction
4-year Evening Course in Chemical Engineering
4-year Evening Course in Electrical Engineering
4-year Evening Course in Machine Design
4-year Evening Course in Mechanical Engineering
4-year Evening Course in Structural Engineering

***FRANKLIN UNION, Boston, Mass. (Endowed)

4-year Evening Course in Building Construction
4-year Evening Course in Industrial Chemistry
4-year Evening Course in Industrial Electricity
3-year Evening Course in Industrial Electricity
3-year Evening Course in Surveying

*LOWELL INSTITUTE SCHOOL FOR INDUSTRIAL FOREMAN, Cambridge, Mass. (Endowed)

2-year Evening Building Course
2-year Evening Electrical Course
2-year Evening Mechanical Course

**UNIVERSITY OF MINNESOTA, Extension Division, Minneapolis, Minn. (State)

4-year Evening Course in Chemical Engineering
4-year Evening Course in Civil Engineering
4-year Evening Course in Electrical Engineering
4-year Evening Course in Mechanical Engineering

**NEWARK TECHNICAL SCHOOL, Newark, N. J. (City and State)

5-year Evening Course in General Chemistry
4-year Evening Course in Architecture
4-year Evening Course in Automotive Engineering
4-year Evening Course in Chemical Engineering
4-year Evening Course in Civil Engineering
4-year Evening Course in Electrical Engineering
4-year Evening Course in Mechanical Engineering

*NEW HAVEN COLLEGE, New Haven, Conn. (Y. M. C. A.)

4-year Evening Course in Building and Construction
4-year Evening Course in Electrical Engineering
4-year Evening Course in Mechanical Engineering
3-year Evening Course in Engineering for Industry

**PENNSYLVANIA STATE COLLEGE, Extension Division,* State College, Pa. (State)

3-year Evening Course in Civil Engineering
3-year Evening Course in Electrical Engineering
3-year Evening Course in Industrial Engineering
3-year Evening Course in Mechanical Engineering
3-year Evening Course in Textile Engineering

***RHODE ISLAND SCHOOL OF DESIGN, Providence, R. I. (Endowed, Public Aid)

4-year Evening Course in Mechanical Design

**RUTGERS UNIVERSITY, Extension Division, New Brunswick, N. J. (State)

3-year Evening Course in Mechanical Engineering

---

* Classes at industrial centers in Pennsylvania.

***VIRGINIA MECHANICS INSTITUTE, Richmond, Va. (Endowed, City Aid)

4-year Evening Course in Architectural Design
4-year Evening Course in Chemistry
4-year Evening Course in Civil Engineering
4-year Evening Course in Electrical Engineering
4-year Evening Course in Mechanical Engineering

**WASHINGTON UNIVERSITY, Extension Division, St. Louis, Mo. (Endowed)

5-year Evening Course in Structural Design
4-year Evening Course in Machine Design

*WESTINGHOUSE TECHNICAL NIGHT SCHOOL, East Pittsburgh, Pa. (Corporation)

4-year Evening Courses in Engineering

UNIVERSITY OF WISCONSIN, Extension Division, Milwaukee, Wis. (State)

3-year Evening Course in Building Design
3-year Evening Course in Machine Design

CORRESPONDENCE COURSES

INTERNATIONAL CORRESPONDENCE SCHOOLS, Scranton, Pa. (Proprietary)

Courses in Civil Engineering, Concrete Engineering, Electrical Engineering, Mechanical Engineering, Mining, Steam and Marine Engineering, and Structural Engineering

MASSACHUSETTS STATE DIVISION OF UNIVERSITY EXTENSION, Boston, Mass. (State)

Courses in Electrical Engineering, Industrial Engineering and Structural Engineering

Geographic Area Now Served.—The present known geographical distribution of schools offering the technical institute type of education, either as the whole or part of their programs, extends in an easterly-westerly direction from Massachusetts to California with Richmond, Virginia as the most southerly point. A few courses in several of the colleges further south are closely related although in length these courses do not meet the definition of the area of education upon which this study was based.

A high percentage of the institute graduates go into various forms of business and industry, in contrast to going into the professions and into non-technical employments. It is, therefore, interesting to note the correlation in the density of locations of these institutions and the centers of population and manufactures of the country as shown by the map, Fig. 1.

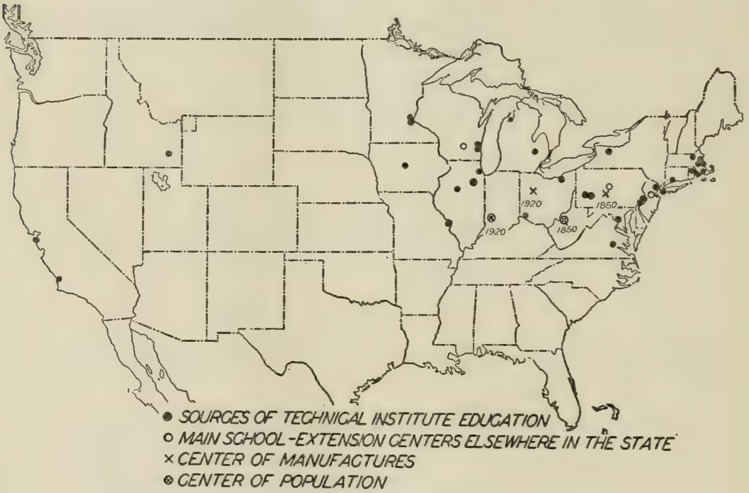

1920
1850
1920
1850
● SOURCES OF TECHNICAL INSTITUTE EDUCATION
○ MAIN SCHOOL-EXTENSION CENTERS ELSEWHERE IN THE STATE
× CENTER OF MANUFACTURES
⊗ CENTER OF POPULATION

FIG. 1. Sources of technical institute education.

Based upon the characteristics of this education and upon the experiences of the past, the major geographical field for technical institutes is in the present dominantly industrial area east of the Mississippi and north of the Ohio and Potomac rivers. In view of beginnings which are being made in the southeastern part of the country and due to the rapid growth in industry in that section development may be expected there. On the west coast several institutions are already offering this type of instruction, and with the expansion of industry other developments may be forthcoming.

In comparison with the present distribution of sources of technical institute education it is interesting to note the geographic distribution of the junior colleges. In 1927 when junior colleges of all types were considered, the Middle West and South led with approximately equal numbers; they were followed by the western and northeastern sections of the country. More junior colleges were reported from California, Iowa, Missouri, and Texas than from others. The number of junior colleges has increased from approximately 125 in 1915 to approximately 400 in 1929, about 100 of which are said to offer engineering courses. While considerable has been said by them concerning the offering of terminal courses, practically none has ventured beyond the usual curriculum of the first and second years of the engineering college, or courses directly preparatory for the third and fourth years of the four-year college. It is entirely probable that certain of these junior colleges may sooner or later enter the technical institute area of education.

IV. A STUDY OF THE TECHNICAL TRAINING NEEDS OF INDUSTRY

Characteristics and Phases to be Studied.—One of the most important divisions of this study has been an attempt to determine the extent of the need for technical institute education.

These technical institutes operate largely on the post-secondary age and preparation levels; their courses are shorter and more directly technical than are those of the four-year engineering colleges, yet they include a substantial treatment of the underlying and related sciences, and usually some work in English and economics although the latter may not be labeled as such; the curriculum content and presentation are more directly related to technical applications than are those of the usual college course; the students are admitted to these courses primarily on evidence of their capacity and interest rather than on formal scholastic credentials.

The practice of actually *doing* is an important characteristic of the instruction; a large portion of the student's time in school, often more than half, is devoted to practice in laboratories, shops, drawing, and design; the courses are intended to train definitely for employment in responsible technical and supervisory positions and do not aim at craft efficiency, neither do they prepare directly for the advanced years of college instruction—thus they may be considered to be of a terminal character; they are usually devised to meet the needs of those having a settled vocational aim, those who for financial or other reasons cannot spend four years or more in preparation for remunerative employment, and those of mature age who from practical experience have discovered their technical bents and have realized their need for systematic technical education; the objectives of the courses are fairly well defined and are expected to prepare for rather immediate service in business and industry.

If employers, in general, cannot effectively use men as they are trained in these courses, the institutes have practically failed in their objectives, for it would appear undesirable to produce, through ineffectual training methods, a larger number of persons with a low degree of employability; on the other hand, if the services of these graduates are in demand and experience shows them to have been reasonably successful, then graduates, employers, and society have profited.

If study shows the former to be true, then in justice to all parties concerned, the development of this area of education might well be discouraged. Since its primary objective is not along broad educational lines, there could be little need, industrial, sociological or individual, for a form of education which would not raise the standard of employability. If study shows the latter, then development might well be encouraged to the extent of the present demand, or to meet the need of undeveloped fields of employment in which the graduates most effectively fit. A successful graduate profits not only himself, but business and industry and the country.

To justify a need for the further development of technical institute education in America, it must be capable of accomplishing definite and desired objectives in furnishing employers with well-trained men and in preparing men to hold positions of considerable responsibility. This is difficult to measure in concrete figures, but data bearing directly upon the training needs of industry, with respect to the technical institute graduate, will be presented as they have been found.

These data are based on the experiences of the technical institutes in attempting to supply the demand, the expressions and experiences of business and industry in employing the graduates, a study of industrial employments in five major manufacturing industries, an analysis of potential fields for employment, and the extent to which needs for technically trained men are being met.

A. THE EXPERIENCES OF THE TECHNICAL INSTITUTES

No Difficulty in Placing Graduates.—The institutes experience no major difficulties in satisfactorily placing their graduates. This is true even though little organized effort is used in their placement. In only a few of the institutions does a designated person devote full or even considerable time to employment problems. When such a person is employed, it does not indicate difficulty in placing current graduates, but rather that he may work along the lines of better and more effective placement; then too, he usually devotes a part of his time to assisting alumni in their employment problems.

Tangible difficulties in the satisfactory placement of graduates are cited by only three institutions. One school, located in a section of the country not in the past highly industrial, comments on the fact that it is difficult to locate its graduates near their respective homes, which it deems desirable. This does not in any way indicate a lack of demand for its product in general, but rather the lack of demand in a restricted area. Two schools refer to some difficulty in convincing new employers of the merits of shorter and more intensive courses before graduates have been tried; after a trial no difficulties in locating others have been encountered.

In Close Contact with Industry.—In addition to the value of the men so trained, the factors of location and industrial contacts contribute to the ease with which they obtain employment. The technical institutes are located principally in industrial areas, and by virtue of the character of the work of these schools they are frequently in close contact with potential employers in their respective communities. A few have reached beyond their fairly local areas and have found more or less permanent contacts in other sections of the country; as a result, they have obtained regular-customer employers for many of their graduates. For example, one of these schools has a standing order from a large manufacturing organization for a complement of five graduates annually. In this case, it is significant, and complimentary to the school, that the company does not interview these men, but accepts them on the judgment of the officers of the school.

Cooperative Students Appear in Demand.—The few technical institutes which have adopted the cooperative plan of education, equal and alternating periods in school and at work, have no employment problem of any consequence for their current graduates. In most cases the students have found satisfactory berths through their industrial employments and contacts long before graduation. Here, the problem is one of employment before enrolling in the school. While the several institutes using the cooperative plan operate in different ways and with different objectives, there is a greater demand from their respective employer clientele than these schools are able to supply.

Graduates of Some Institutes in Greater Demand than Others.—As in any other group of educational institutions, the graduates of certain ones appear to be in greater demand than are the graduates of others. To some extent this may be due to original selection of students where future employability is stressed as one of the requisites for entrance. However, a study of the reactions of employers indicates that any apparent greater demand is not always due to a superior school or product, but is frequently the result of a school's strategic location, long establishment, types of courses, and effective and reliable publicity.

Demand Exceeds Supply.—The demand for graduates by employers as reported by the schools exceeds the supply in several cases by the ratio of two to one. Contrary to the large majority, three schools reported that the active demand did not exceed their supply. It so happens that two of these three schools are located in geographical areas not largely industrial; the other one is located in an industrial section but where the principal industry, for which it primarily trains, has not been conspicuously prosperous in recent years. Of course, there may be many additional reasons why the demand does not exceed the supply with these particular schools.

The ease with which graduates of the technical institutes are satisfactorily placed and the more positive factor of the current demand, in general, exceeding the supply, as reported by the schools themselves, indicates a field for considerable expansion.

B. Needs of Business and Industry

New Jersey Selected for Study of Industrial Requirements.—The State of New Jersey was selected for a study of industrial requirements for technically trained men because of its diversity of industries and its proximity to the office of the investigation. In addition, it is a part of a section where the technical institute graduate is as well, and probably better, known than he is in any other industrial section which might have been chosen.

In a survey * made in 1926, this question was asked of a considerable number of manufacturing companies in New Jersey:

> *"How many positions are there in your establishment for which you prefer personnel with training beyond that offered by high schools in the following basic or technical fields?"*

The data studied came from forty-eight manufacturing companies. These companies ranged from some fairly small to others quite large, and included practically every line of industry. Only such data were used as appeared over the signatures of responsible officers of the companies; and in the great majority of instances the material showed considerable care and study in its preparation. None of the material bore the earmarks of being casually thrown together.

---

* Survey conducted in 1926 by the U. S. Bureau of Education at the request of Rutgers University; certain original data from this survey, through the cooperation of the U. S. Bureau of Education and Rutgers University, were made available to the staff of the S. P. E. E. for analysis and study.

RATIO OF TECHNICAL INSTITUTE MEN TO FOUR-YEAR COLLEGE MEN PREFERRED BY FORTY-EIGHT MANUFACTURING COMPANIES IN NEW JERSEY

	Number of Men Preferred from	
Fields of Employment	*Technical Institute (Beyond high school—less than four-year college)	*Four-year College or Beyond
Mechanical	817	316
Electrical	116	111
Civil Engineering	6	18
Chemical	345	146
Mining	6	4
Miscellaneous	12	0
Total	1,302	595

* Ratio (Technical institute men to four-year college men), 2.2 to 1.

Particular attention is directed to the ratio of technical institute trained men to four-year college trained men preferred by these forty-eight manufacturing companies in New Jersey. This was the first quantitative analysis in the present study of industry's needs for technically trained men, and the fact that it resulted in a preference, on the part of the industries, for two and two-tenths technical institute men to one from the four-year college or beyond, appeared significant only as a ratio. As the study progressed, however, later analyses checked it very closely.

An interesting by-product of the above tabulation is that by far the greatest need for technically trained men in these New Jersey industries appears to be in mechanical fields. This holds true for both technical institute and college trained men. The chemical and electrical fields hold the second and third places respectively; civil engineering scarcely figures at all, and it is the only group in which the preference for college men outnumbers that for technical institute men. The relatively small number indicated in the civil engineering field is not at all surprising when it is considered that these are the civil engineering requirements in the manufacturing industry.

Data Gathered by the College of Engineering, Rutgers

University.—In 1926, the College of Engineering at Rutgers University made an inquiry into the technical training needs in New Jersey. The following letter was addressed to a number of industries within the State:

RUTGERS UNIVERSITY
New Brunswick, New Jersey
COLLEGE OF ENGINEERING
OFFICE OF THE DEAN

November 10, 1926.

Gentlemen:

You are doubtless aware that the whole matter of Engineering Education has been subject to a study and investigation during the last three years under the joint auspices of the Carnegie Corporation and of the Society for the Promotion of Engineering Education.

Among many other subjects of investigation the question has arisen as to the need of a type of engineering education that may be designated as ''intermediate'' between the usual college type and training for mechanics, for instance, a type represented perhaps by Pratt Institute of Brooklyn and Wentworth Institute of Boston, covering two or three years but not leading to a degree, but supervised or carried on by the colleges of engineering, either in residence or as extension in nearby industrial centers. Assuming that an ''intermediate'' type of engineering training were available at Rutgers, in which the course was of less length than the usual one of four years and in which greater emphasis was placed on immediate utility and practice rather than on theoretical and mathematical principles, with more and earlier training in drafting, surveying and shop computations, would such a course fill a need and if so, what would be the probable call for men trained in such short courses, in the industries of New Jersey, and particularly in your organization?

Etc.

Very sincerely yours,

(Signed) Edward H. Rockwell,
Dean

The original completed questionnaires from this inquiry were made available to the staff of the Society for study and tabulation. Again, as in the previous study, only those replies reasonably complete were considered for final analysis. The data came from twenty-one manufacturing companies with a total of 34,000 employees. A wide range of industries was represented, and the size of companies varied from 300 to 6,500. In a number of cases it was evident that special studies had been made of the employed personnel in order to arrive at the percentages requested.

Question asked:

> "*In order to maintain the efficiency of your organization, what percentage of your employees ought to possess a technical education or training of each of the following types?*"

RATIO OF TECHNICAL INSTITUTE MEN TO FOUR-YEAR COLLEGE MEN DESIRED BY TWENTY-ONE MANUFACTURING COMPANIES IN NEW JERSEY

Composite Reply	Types of Education		
	*Technical Institute	*Four-year College	Elementary, Manual and Industrial Courses
Percentage of total employees needed......	6.0	2.2	14.8

* Ratio (Technical institute men to four-year college men), 2.7 to 1.

Question asked:

> "*Is there need for technical institute education in New Jersey?*"

Replies:

Yes	18
Uncertain	2
Not answered	1

In this particular study the ratio of technical institute men to four-year college men, desired by the industries, is two and seven-tenths to one. In the previous study it was two and two-tenths to one.

The similarity of the two ratios is interesting, since the original data were collected by different agencies and were in answer to different questions put to a different group of manufacturing companies, all however, located in New Jersey. These same twenty-one employers indicated that fourteen and eight-tenths of their employees should have elementary manual and trade training to maintain the efficiency of their respective organizations. No comparisons are being made with this figure; it has been included only as a related item of interest.

In reply to the question asked this group of manufacturers, whether there is need for technical institute education in New Jersey, the answer is impressive. Eighteen replied in the affirmative, two were uncertain, one did not answer, and there were no direct negatives. It might be inferred that they, more or less, automatically replied in the affirmative, were it not for the fact that to another question directly following the one above, but not bearing on the technical institute, their replies were distinctly negative in trend. This, at least, indicates that some degree of discrimination was exercised.

The duties or positions in which these technical institute men might be useful are reflected in typical excerpts from the employers' letters in connection with the above studies. From a well-known metal and equipment manufacturing company:

> ''There is need for educated men in manufacturing circles today in the capacity of foremen, superintendents and plant managers. Any course of study tending to develop such men would afford the manufacturer an opportunity to operate more economically. Such men should be qualified to readily determine operating costs, methods of waste elimination, etc.''

The Works Manager of a large machine manufacturing company comments:

> ''We believe that there is a need for a type of engineering education 'intermediate' between the practical training given apprentices in technical lines and the usual engineering courses offered by colleges and universities, and in our opinion such

> schools as Pratt Institute and Newark Technical School are working in a field of great usefulness.
>
> "Technical courses beginning where the high schools leave off and covering several years of specialization in mechanical, electrical, chemical and automotive subjects would meet an ever-increasing demand.
>
> "In courses of this kind, higher mathematics—such as differential and integral calculus—would not need to be essential, and the time saved by the omission of such subjects could be devoted to the study of metallurgy, modern methods of material handling, the rudiments of sound mechanics, and commercial history. After entering the industries of the state, graduates of 'intermediate' courses of the type under consideration, we believe, would soon develop to the point where they would be competent to hold positions as foremen, assistant department heads and inspection overseers."

These two studies, covering sixty-nine companies with nearly 100,000 employees, diversified as to product manufactured and size of plant, may be considered as furnishing a fair cross-section of American manufacture. The accuracy of the data possibly may be questioned since it came from many sources, and in some cases may have been prepared by those not altogether conversant with the problems under consideration; quite likely some may have interpreted the questions differently from others. However, it is probably the most comprehensive data on technical training requirements for manufacture yet obtained. It will be interesting to see how closely industries other than those of manufacture check the above ratios of technical institute men to college men.

Needs of Public Utility Companies in New Jersey (Not Including Communication).—It appeared desirable to determine technical training needs in New Jersey from an industry other than those normally listed under private manufacture. A large public utility organization was asked for data on requirements for technically trained men in its various divisions. The financial and commercial departments, the department which manufactures and distributes gas, the electric operation division including the generation and distribution departments and laboratory, and the division in charge of bus and trolley operation, maintenance and construction, cordially responded. These units employ more than 16,000, and probably furnish a fair sampling of private companies engaged in public utility service. It is worthy of note that one hundred per cent of these public utility units addressed in New Jersey, replied furnishing complete data as requested. The questions asked, as to requirements for technical training, were planned to make the replies directly comparable with those from the manufacturing industry of the same state.

Question asked:

> *"In order to maintain the efficiency of your organization, what percentage of your employees ought to possess a technical education or training of each of the following areas?"*

RATIO OF TECHNICAL INSTITUTE MEN TO FOUR-YEAR COLLEGE MEN DESIRED BY A LARGE PUBLIC UTILITY ORGANIZATION IN NEW JERSEY

	Areas of Education	
Composite Reply	*Technical Institute	*Four-year College
Percentage of total employees needed..	8.3	3.1

* Ratio (Technical institute men to four-year college men), 2.7 to 1.

The estimated required percentages of college trained men varied from one per cent of the employees in bus and trolley operation, maintenance and construction, to six per cent in the electric operation division; the technical institute requirements varied from one-half of one per cent of the employees in the financial and commercial departments to fifteen per cent in bus and trolley operation, maintenance and construction.

For the industry, the technical training requirements indicated that to maintain efficiency, three and one-tenth per cent of the employees ought to be college trained, and eight and three-tenths per cent ought to be technical institute trained. Therefore, the ratio of technical institute men to college men appears to be two and seven-tenths to one in the public utility industry in New Jersey.

Question asked:

"Is there need for technical institute education in New Jersey?"

Replies:

Yes .... 100 per cent

In connection with these data submitted a vice-president comments:

> "In the laboratory, which employs about 130 men, 50 per cent ought to be graduates of four-year engineering courses and 30 per cent graduates of two-year courses. Men with less than a high school education are usually not employed."

Corroborating Data from California.—In 1926, a list of positions was furnished twelve employment managers of the same number of large corporations in California, and each was asked to indicate the number of employees in his company for each position listed. The list contained seventy-five different positions, thirty-two of which were believed to require four years of college preparation, and forty-three were believed to need, in the language of the questionnaire, only two years of college work. This segregation of positions was made on the basis of a study at the University of Minnesota in which one hundred deans of schools of engineering were asked to participate in classifying positions as to training requirements.

The tabulated result from the twelve companies showed 755 employees in positions believed to require only two years of college, and 289 employed in positions believed to require four years of college work.

RATIO OF POSITIONS FOR TWO-YEAR COLLEGE MEN TO POSITIONS FOR FOUR-YEAR COLLEGE MEN IN CALIFORNIA

	Actual number of men employed in	
Study in California by Frank Waters Thomas	*Positions believed to require only two years of college work	*Positions believed to require four years of college work
Of twelve corporations	755	289

* Ratio, 2.6 to 1.

This ratio of two and six-tenths positions for two-year men to one position for four-year college trained men closely corroborates ratios from the three New Jersey analyses made by the staff of the S. P. E. E. in 1929.

Undoubtedly the majority of deans of engineering, in deciding whether a position required two or four years of college work, were thinking in terms of the first two years of the usual college engineering course, and not the technical institute course which is also post-secondary. Actual practice would probably show the technical institute terminal course suited to a larger number of positions than the two-year college course which was used as a "measuring stick." Such a revision would probably increase the ratio to those obtained in New Jersey.

It is significant, almost incredible, to find four ratios, resulting from four studies conducted at different periods under different circumstances in different industries, even in different parts of the country, so nearly alike in size—respectively 2.2 to 1, 2.7 to 1, 2.7 to 1 and 2.6 to 1. As a further check, the technical "positions vacant" advertised in the New York Sunday Times, over a period of several months, were tabulated and classified into two groups believed to require two and four years of engineering training respectively. This resulted in a ratio of a little less than 3 to 1.

An Analysis of Technical Training Needs of an Engineering and Construction Company.—A large engineering and construction company in public utility and general engineering and construction work, located in New Jersey, submitted an analysis of its training requirements. These data are not only worth showing in their entirety, but they will also indicate the completeness and care with which much of the New Jersey data were obtained.

TYPES OF TRAINING REQUIRED BY AN ENGINEERING AND CONSTRUCTION COMPANY IN NEW JERSEY

Types of Training Needed to Maintain Efficiency of Organization	Electrical Dept.	Mechanical Dept.	Construction Dept.	Drafting Department				
				Piping Div.	Architectural Div.	Mechanical Div.	Electrical Div.	Structural Div.
(*a*) Four-year engineering course leading to a degree.........	80%	70%	8%	75%	None	30%	25%	60%
(*b*) Short courses in engineering or technology, of less than four years, more practical than (*a*)...	20%	30%	5%	25%	100%	70%	75%	40%
(*c*) Industrial courses almost entirely manual and extremely elementary..........	‡	‡	65%†	‡	‡	‡	‡	‡
(*d*) Do you think there is a need for technical education of this type (*b*) in N. J.?.............	Yes	Yes	Yes	Yes	Yes*	Yes	Yes	Yes

* We consider that the course now given by the Newark, New Jersey, Technical School in the evening is adequate for the needs of one studying architecture; however, a day course would seem desirable.

† The remaining 22 per cent of the total of the Construction Department would normally be made up of common labor.

‡ Under some conditions it is possible to use help in these departments of purely clerical nature. The percentage of such employees, however, will probably not exceed 5 per cent to 10 per cent of the total department, exclusive of stenographers.

Countrywide Industries Asked for Experiences.—In order to check the results obtained from local areas as to the needs for further development of technical institute education in the United States fifteen representative companies believed to have had experience with graduates from this area of technical education were selected. It was found that twelve of these had considerable experience as was anticipated; two had some experience; the remaining one did not have enough to justify any expression.

These companies were located in the states of Connecticut, Illinois, Indiana, Iowa, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania and Vermont. The size of the companies ranged from 400 employees to one of the largest in the country; the kinds of industries included food, glass, electrical equipment, electric power, motor cars, sporting goods, silverware, textiles, abrasive material, paper, light and heavy machinery, etc. These companies were asked, whether from their experience they felt that an area of terminal technical education, intermediate in years, between the vocational and trade schools on the one hand and the engineering colleges on the other hand, should be encouraged and developed in America. The replies were unanimous in the affirmative.

A large manufacturing company employing these graduates in considerable numbers comments:

> ''We have a lot of supervisory and technical routine jobs for which technical training is necessary, but for which college men are overtrained. These men are more liable to be permanently satisfied on such work than college graduates who consider these as training jobs for engineering.''

Another from an electric power company:

> ''If this type of education could be brought in general to a greater degree of perfection, it should certainly prove most beneficial to all concerned.''

From a textile manufacturing company:

> ''We feel that there is a very decided field for a course of technical education which is between the vocational and trade schools on the one hand, and the engineering colleges on the other. We are certain that the young men who would have this background would be precisely the type to become the foremen and junior executives of industry.''

In so expressing themselves, several indicated the desirability of evening instruction in this field for adults already at work. Two suggested the further development of the cooperative plan for technical institute education.

Since these fifteen companies expressed themselves one hundred per cent in favor of encouraging the further development of technical institute education, it will be instructive to note the relative order of importance of the aims indicated by them for such training.

Aims Suggested for Technical Institutes

	Composite Employer's Estimation of Relative Importance
(*a*) To qualify men for supervisory positions in operating departments	1.00
(*b*) To qualify for technical service, such as drafting, designing, testing, inspection, etc.	.74
(*c*) To qualify for commercial positions relating to the sale of technical products and services	.56

In reply to the query whether they would prefer men graduated from a *general* course, covering a fairly wide field of study and intended to qualify men for a wide variety of work, or, from a *specialized* course, covering intensively a particular line of work, the result was seven in favor of *specialized,* five for *general,* and three did not express themselves.

Typical comments on this question were:

> ''Valuable men come from both types. Better men would come from a combination of the two types.''
>
> ''Those specialized usually have an objective and know where they want to go.''
>
> For operating departments, the course should be general; for technical service, specialized.''
>
> ''From a general course, they are much more adaptable to a variety of situations and generally possess analytical ability.''
>
> ''Specialized course men are able to immediately apply their education on the special work or branch of engineering. The absorption of 'general' material follows, and meanwhile they are usefully at work.''
>
> ''We don't know how long we may want to use him on the specialty if his training has been specialized. We want him to be adjustable from a general course.''
>
> ''For work requiring broad or general education background, we use college trained men.''

On this question, there are neither enough numbers nor sufficient unanimity of opinion to justify conclusions as to which type of course is really preferred.

C. NEEDS BASED ON STUDY OF INDUSTRIAL EMPLOYMENTS

A Study of Five Manufacturing Industries.*—An analysis was made of the training had by those holding supervisory and technical positions in five major manufacturing industries.

PERCENTAGES OF TECHNICAL AND SUPERVISORY POSITIONS IN MANUFACTURING FILLED BY COLLEGE TRAINED MEN OF DIFFERENT TYPES

Manufacturing Industries	Number of Plants Covered	Total Employees Covered	Technical and Supervisory Men Analyzed	College Trained — Technical	College Trained — Non-technical	College Trained — Total in Technical and Supervisory Positions
Chemical industry.....	142	35,000	5,511	23.7%	6.1%	29.8%
Elec. manufacturing...	149	153,000	22,913	32.8	4.3	37.1
Metal trades..........	318	106,500	16,002	12.3	4.8	17.1
Paper and pulp.......	156	35,000	2,662	13.0	9.0	22.0
Rubber industry......	113	100,000	6,869	11.1	12.7	23.8
The five industries.....	878	429,500	53,957	22.1%	5.9%	28.0%

The chemical, electrical, metal trades, paper and pulp, and rubber industries are fairly representative of the manufacturing field. The numbers of plants and employees covered in each were large enough to furnish a fair picture of the training situation. Technically trained college men holding technical and supervisory positions greatly outnumber the college men not technically trained, with one exception—the rubber industry. For the five industries, the technically trained men outnumber the non-technical men nearly four to one. Only a little better than one out of four in the technical and supervisory positions of these five industries have had college training, either technical or non-technical.

Of these five industries, the electrical manufacturing industry seems now to be the most highly recruited with college trained men, while the metal trades industry appears to be the least highly recruited; the percentage in electrical manufacturing is more than twice that in the metal trades.

---

* Data for the study of these five industries secured through cooperation and courtesy of the National Industrial Conference Board.

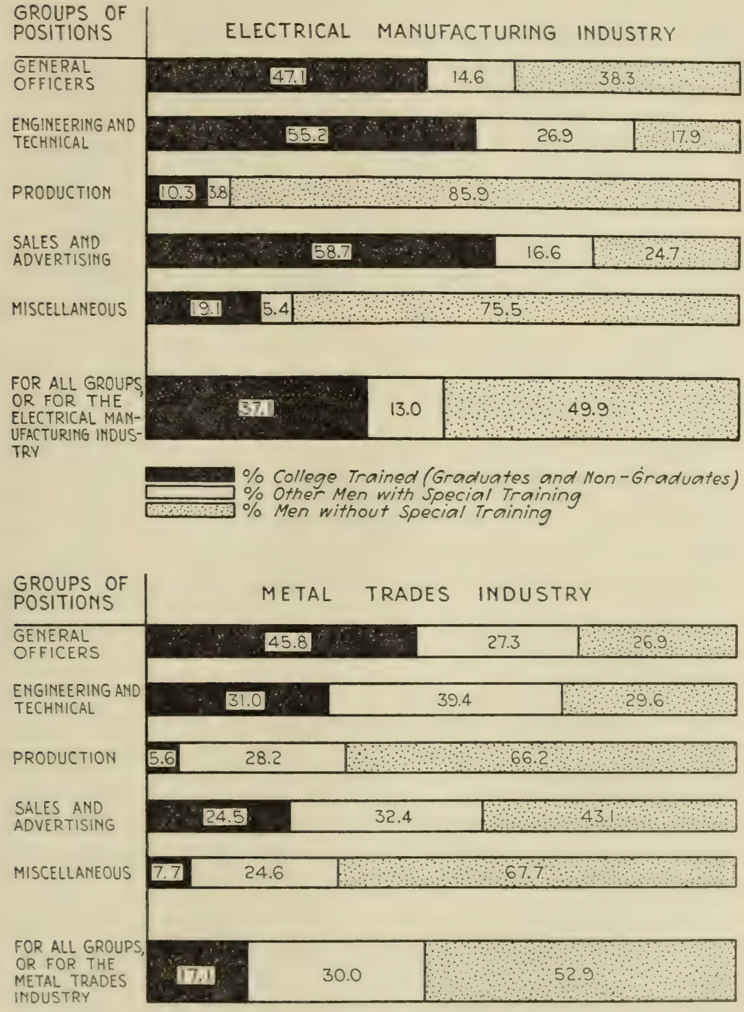


FIG. 2. Training possessed by men in technical and supervisory positions.

The data studied unfortunately did not show the distribution of technical institute trained men; but they did show the distribution of four-year college men, trained in both general and technical courses, in various groups of positions or function of these five industries.

Percentages of Technical and Supervisory Positions in Manufacturing Now Held by College Trained Men

Groups of Positions	Chemical Industry	Electrical Manufacturing	Metal Trades	Paper and Pulp	Rubber Industry	Total of the Five Industry
General officers....	65.0%	47.1%	45.8%	32.8%	43.9%	46.6%
Eng. and technical..	57.2	55.2	31.0	50.4	55.2	48.6
Production........	*17.6*	*10.3*	*5.6*	*10.4*	*9.4*	*9.3*(Lowest)
Sales.............	23.4	58.7	24.5	15.3	19.3	38.4
Miscellaneous.....	11.6	19.1	7.7	9.5	23.5	13.8
For the industry...	29.8%	37.1%	17.1%	22.0%	23.8%	28.0%

Many interesting observations may be made from this table, a number of which will be discussed in other connections; but the one outstanding and significant fact which cannot escape attention is that four-year college trained men are not largely engaged in production work in industry. Of all the groups, production has by all odds the smallest percentage of college trained men in supervisory and technical positions. There are but two exceptions, that of "miscellaneous" in the chemical and paper and pulp industries, which in themselves are insignificant. While these data take into consideration only supervisory and technical positions, relatively few four-year college men are employed in industry other than in such positions, and the percentages would probably be changed very little were these numbers available.

Trained Men in Production.—In view of the conspicuous absence of college men in production work, are they actually needed for supervisory and technical positions in this function of industry?

At six conferences held during the year and attended quite largely by industrial executives and others conversant with industry, the question of whether production needs trained men in the same proportion as do the general administration, engineering, sales, and other functions, was asked before any figures were shown. Unanimously, they agreed that production most certainly does need trained men and more of them. This need in production is definitely reflected in the growth of foremanship courses during the past decade.

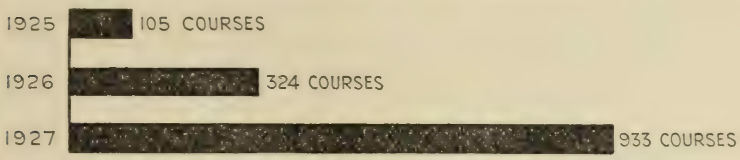


FIG. 3. Growth of foremanship courses.*

While these foremanship courses are practically never of the technical institute type, the realization of a definite need for better trained supervisory forces in business and industry has brought about the large increase in foremanship courses. The foreman's position, of course, is only one of a number coming under production, yet it is one of the largest in point of numbers. The industries had their foremen, they saw the need for better trained foremen, it was impractical to make wholesale changes and, provided they did, where were they to obtain men with proper training? The only practical and immediate alternative was to attempt to train their present foremen in whatever ways were available and look to the future for replacements to furnish more highly trained men. As a matter of fact, however, industry has not obtained college trained men in any sizable numbers for any of the positions in production in the past; it is not obtaining them at the present

Technically Trained College Men Predominate in Production.—As might be expected, the technically trained college men greatly outnumber the non-technical college men in supervisory and technical positions in the production group, about three and six-tenths to one. The predominance of technically trained college men is most marked in the chemical industry, where the ratio is eight to one. As the electrical manufacturing industry appeared to be the most highly recruited, as an industry, with college men and the metal trades the least, so electrical manufacturing is the most and metal trades the least highly recruited with college men in production positions.

---

* From "Growth of Foremanship Courses in the U. S.—1927," published by the Chamber of Commerce of the United States.

PERCENTAGES OF TECHNICAL AND SUPERVISORY POSITIONS IN THE PRODUCTION FUNCTION OF MANUFACTURING INDUSTRIES FILLED BY COLLEGE TRAINED MEN OF DIFFERENT TYPES

Production Function in Manufacturing Industries	Technical and Supervisory Positions Filled by		
	College Trained, Technical	College Trained, Non-technical	College Trained, Total in Production
Chemical industry	15.7%	1.9%	17.6%
Electrical manufacturing	8.2	2.1	10.3
Metal trades	4.8	0.8	5.6
Paper and pulp	7.2	3.2	10.4
Rubber industry	5.1	4.3	9.4
The five industries	7.3%	2.0%	9.3%

Reasons for Absence of College Men in Production.—Several reasons for the absence of college trained men in production have been advanced. The usual longer hours and the working conditions in the factory do not appeal to the college trained men, particularly should those with whom they associate happen to work in the offices. They consider the production department as a sort of "blind alley" and are inclined to believe that it does not offer equal opportunities for promotion as do other functions or departments. They believe that the salary opportunities are not on a par with other departments.

One of the most plausable reasons why college men are not found in production work in industry in large numbers probably traces back to the instruction which they received in college. The average college student is encouraged and taught to think through situations and to determine largely the "whys." Much time is spent and emphasis placed upon the extended analysis of problems, the gathering of data and facts upon which a final decision may be based in due time. In the end, it is true, this type of decision may be more accurate; but, as a rule, production requires quick decisions, sometimes with meagre facts, and with no time to wait for a thorough study of the situation. It is extremely doubtful whether the usual college instruction best fits a man for the production department in a manufacturing plant. Many contacts and reactions obtained during the present study appear to justify such a statement.

Technical Institute Graduates in Production.—When the graduates of the technical institutes were studied, it was noted that, in contrast to the college men, they were working largely in production. The percentage of technical institute graduates in production was the largest among the groups of positions for all of the alumni bodies studied, with one exception. Even this exception shows between two and one-half and three times the percentage of graduates in production as is indicated for engineering and non-engineering trained college men. This may be accounted for in part by the fact that technical institute instruction is more direct in method and more practical in content than the usual college instruction. It aims more particularly at teaching how to do certain things than it does in determining the "why." The college student learns largely through reflection—thinking out; the technical institute student largely through action—doing.

Aside from production, it is interesting to note in Fig. 4 that the sales and advertising function claims a large percentage of the non-engineering and engineering college men in contrast to its claim upon technical institute men. It should not be overlooked that large percentages of the technical institute graduates are in engineering and technical employments. In fact, the percentage of graduates in engineering and technical employments from each of the two-year engineering courses at Pratt Institute, is larger than the percentage of engineering college men employed in engineering and technical work.

From all data collected and studies made, it is evident that technical institute graduates are excellently qualified for technical and supervisory work in the production function of industry. Facts show that a very much larger per cent are entering and remaining in production than are college trained

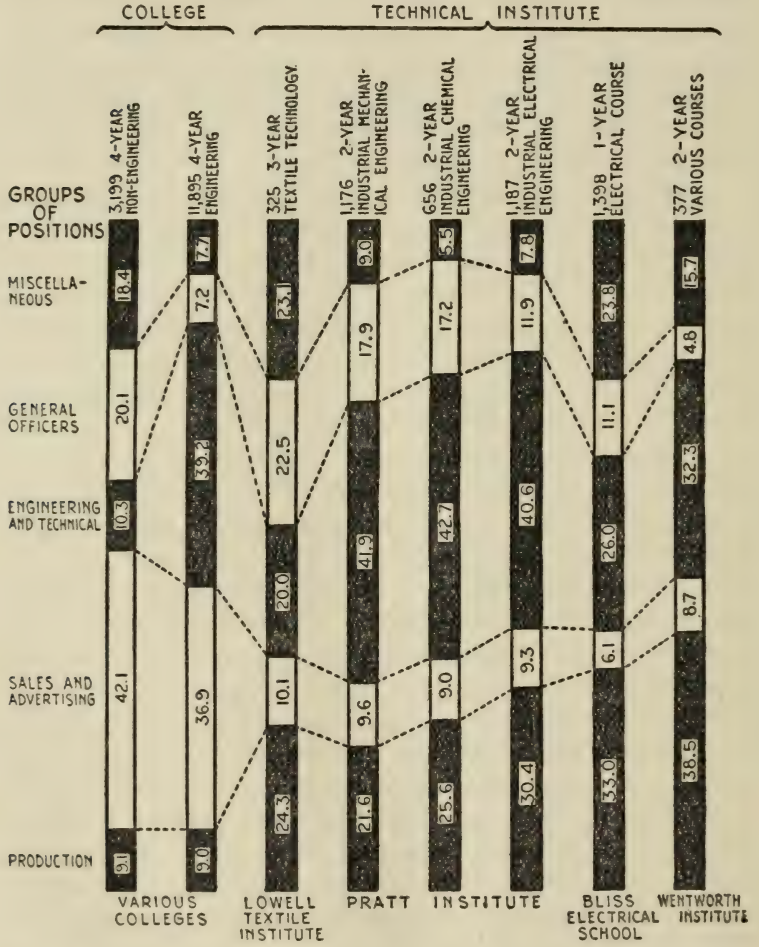


FIG. 4. Distribution of college and technical institute men in the various groups of positions in industry

men, including college engineering graduates; yet, actual numbers of technical institute men are small since at this time there are not more than 15,000 technical institute graduates in America who have been educated in American institutes. Production's share of these men is a number absolutely insignificant compared with the need. The fact remains that college trained men from whatever courses, have not in the past, are not at the present, and, possibly may not in the immediate future, supply this need in production. There is only one other source of training in the American higher educational field which probably trains as well as the engineering college, or even better, for technical and supervisory positions in operating departments—the technical institute.

At the same time, in studying the factual data, opinions of employers, and reactions of the graduates themselves, we must not overlook the fact that there are additional needs aside from production; plant maintenance and technical services such as drafting, detailed designing, laboratory testing, technical inspection, construction and erection in the field, and technical sales are all places upon which little doubt has been expressed as to technical institute graduates succeeding and being very desirable. The fact cannot be disputed that many of the graduates have succeeded in other lines of technical and engineering work; yet, opinion is fairly well in agreement that their large field and opportunity lies in the area of work from which typical employments were named above.

D. Potential Fields for the Employment of Technical Institute Graduates and Extent to which Needs are Being Met

Industries and Businesses Now Employing Technical Institute Graduates.—Knowing in what fields technical institute graduates are largely working at the present time, may afford some indications as to potential fields and where they may be used advantageously to both employer and employee.

TABLE I

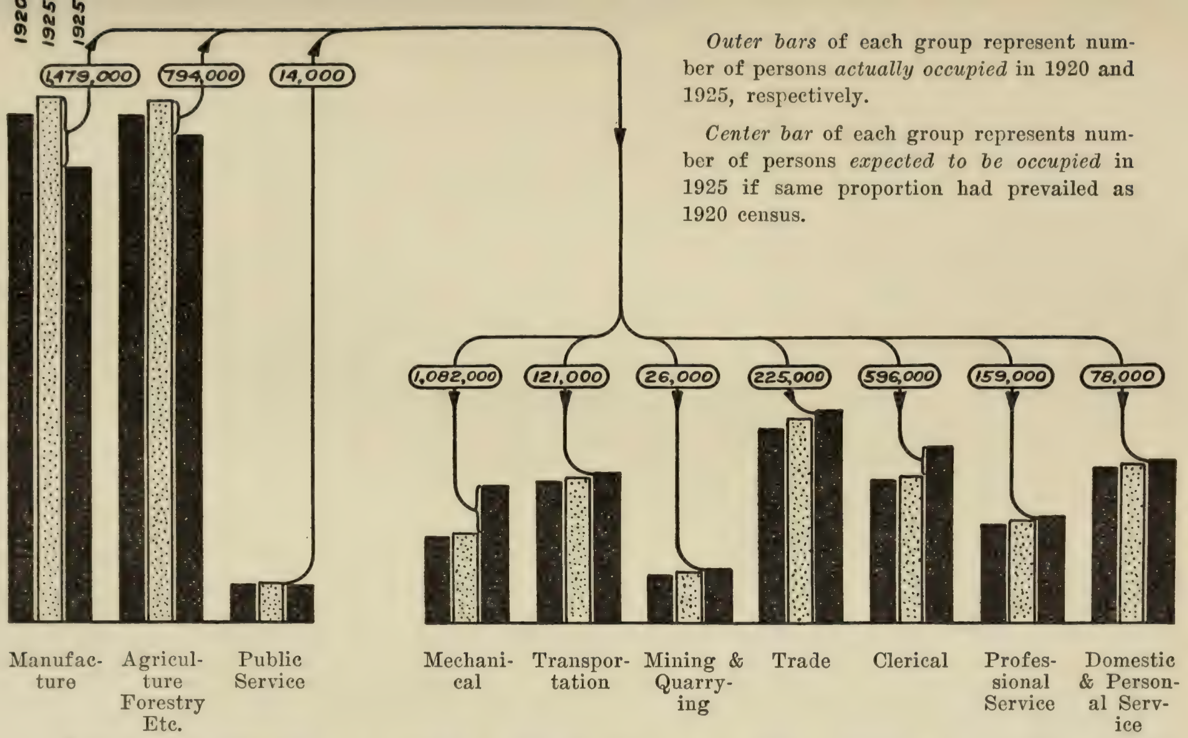
FIELDS HAVING GRADUATES FROM FIVE TECHNICAL INSTITUTES

Machinery and equipment manufacture	569
Electrical manufacture	376
Transportation and communication	357
Generation of power	333
Manufacture of materials	242
Automotive manufacture	179
Erection and installation of equipment	166
Chemicals and chemical products manufacture	142
Gas and oil manufacture	134
Federal, state, municipal	113
Metal and metal materials manufacture	84
Insurance and safety	73
Leather manufacture	65
Structural	64
Education	63
Textile manufacture	59
Heating and ventilation	49
Rubber manufacture	40
Refrigeration	14
Miscellaneous (Technical and non-Technical)	342
	3,464

At least 54.6 per cent of the graduates now in the above fields are located in manufacture, or a total of 1,890 men out of the 3,464.

It might be expected that the graduates of a short intensive electrical course would be found employed in the electrical industries. An examination shows this to be true to a large degree; however, they are often employed in electrical work in other industries. Less than one-third of the alumni from the specialized electrical course studied in this case were found in electrical manufacture, between a fifth and a sixth in transportation and communication, and one-eighth in the generation of power; the remaining graduates were in diversified industries.

Of the alumni from the textile institutes studied sixty-six per cent were employed in some phase of textile manufacture; the remaining thirty-four per cent were distributed in other



Outer bars of each group represent number of persons *actually occupied* in 1920 and 1925, respectively.

Center bar of each group represents number of persons *expected to be occupied* in 1925 if same proportion had prevailed as 1920 census.

Sources of Information: U. S. Census of Manufactures, U. S. Decennial Census, U. S. Bureau of Labor Statistics, National Industrial Conference Board.

N. B.—*Public Service:* Federal, state, county, city officers, police, sheriffs, etc. *Mechanical:* Carpenters, engravers, tailors, garage mechanics, radio service, etc. *Trade:* Brokers, salesmen, undertakers, retail and wholesale dealers, etc. *Clerical:* Collectors, bookkeepers, cashiers, messengers, stenographers, etc. *Professional Service:* Actors, chemists, clergymen, lawyers, engineers, etc. *Domestic and Personal Service:* Barbers, boot-blacks, janitors, waiters, etc. Other classifications are self-explanatory, or see U. S. Census Reports.

FIG. 5. Numbers and trends of persons gainfully occupied in the U. S. A., 1920–1925.

industries, some of which were closely related to textiles such as textile equipment, etc.

Potential Fields Estimated from U. S. Census Data.—The potential fields for the employment of technical institute graduates are, in the final analysis, dependent upon the numbers gainfully employed under the various classifications of occupations. For this study the classification by the U. S. Census Bureau will be used. Figure 5 shows numbers of persons gainfully employed as well as the trend or shift during the five year period from 1920 to 1925. This will indicate which are the larger potential fields for the employment of technical institute graduates.

Agriculture, Forestry, and Animal Husbandry.—Relatively few technical institute graduates are now employed under this listing. The present training is not primarily intended to fit for these occupations and lines of industry. There appears to be some opportunity for expansion, particularly in the direction of technical services.

Extraction of Minerals.—Extracting minerals is primarily a production function for which the technical institute graduates are well trained. Technical training of any kind is highly useful in many phases of the work; there are many positions which do not require college graduates, but do need men trained in the technology of the industry.

In this country, we have not been compelled to conserve these natural resources to the same extent as in other parts of the world; consequently, we have not found it expedient in the past to pay much attention to the technical phases involved. With supply plentiful, we have not been compelled to mine or extract the smaller deposits efficiently. Colleges of mines are supplying mining engineers, but to the present there are no technical institutes in this country parallel to the *bergschulen* for coal mining in Germany which supply the supervisory positions in the industry. These positions are sometimes referred to here as semi-professional. As our supply of minerals in the United States becomes more and more depleted and more difficult to extract, better trained personnel will unquestionably be required. Several significant beginnings in technical institute type of training in the mining industry have already been begun with what are reported to be good results.

It is observed that the great majority of persons engaged in the extraction of minerals are found in the eight industries listed in Table II. These should be potential fields for the technical institute type of education. The field of employment for these graduates then would lie in the fifth column, "Total Proprietors and Salaried Employees." In this column are included approximately 37,000 foremen, overseers, and inspectors.

TABLE II

PERSONS ENGAGED IN THE EXTRACTION OF MINERALS—PRODUCING ENTERPRISES (1919)

Kind of Industry	Proprietors, Officers	Superintendents and Managers	Technical Employees	Subordinate Salaried Employees	Total Proprietors, Salaried Employees	Total Persons Engaged in the Extraction of Minerals
Coal, bituminous	10,107	9,750	2,546	15,407	37,810	583,608
Petroleum and natural gas	16,615	4,704	868	9,718	31,905	125,110
Coal, anthracite	392	2,821	907	3,390	7,510	154,882
Copper ore	288	596	717	1,681	3,282	46,999
Iron ore	171	616	499	1,740	3,026	48,767
Limestone	1,008	672	47	909	2,636	24,705
Lead and zinc	578	547	249	772	2,146	24,030
Gold and silver, lode etc.	948	505	240	402	2,095	17,531
Total of above	30,107	20,211	6,073	34,019	90,410	1,025,632
Total persons engaged in the extraction of minerals	32,374	21,704	6,331	35,706	96,115	1,077,675

Naturally, some of these positions should be filled with college graduates and many from the ranks, but there are large numbers for which a technical institute education would be ample and desirable.

For the extraction of minerals there are no figures available indicating what percentages of the employees should be college and technical institute graduates respectively to operate efficiently as indicated for manufacture and public utilities earlier in this report. If the salaried employees in extraction of minerals are divided in the same ratio as the salaried employees in manufacture, the training required would appear to be about as follows for the present numbers employed:

College trained	13,404
Technical institute trained	36,191
From the ranks and other forms of training	46,520
Total salaried employees in the extraction of minerals	96,115

The kinds of positions and types of work performed by the salaried employees of this industry would indicate that the above requirements are not unreasonable, particularly, when it is considered that the tendency is to pay more attention to the improvement of mechanical processes in extracting minerals.

This analysis indicates that there are about 36,191 positions in this industry which probably should be filled by technical institute graduates. While a few such graduates have found their way into the industry, there has been no source in this country for supplying these needs in the mining field.

Based on the foregoing data the industry could absorb approximately 1,000 technical institute men annually for replacement alone. These would mainly be positions of considerable importance in which the college trained man does and will not stay put.

In this connection, the anthracite coal industry, while not the largest of the mineral extraction group, by virtue of its compactness geographically, presents interesting possibilities. Following the same ratios used in manufacture and public utilities the anthracite industry for the most effective operation should have in its employ about 3,000 technical institute graduates, and these would not interfere with positions which generally should be filled with the college man. Its annual replacement requirements might well be 100 such men, and that number would unquestionably justify the establishment of a technical institute type of school. Its location should be in one of the cities in the immediate anthracite region. Not entering into details, but with the proper cooperation of the employing companies an admirable setting appears to be presented for the use of the cooperative plan of education, where a period at work alternates with a period in school. After a study of the technical institute area of education and its applications, both here and abroad, such a development would seem not only practical but highly desirable from the standpoints of both employer and employee. These suggestions are capable of enlargement, and they are made in due consideration of the trade or craft instruction of the Smith-Hughes type, which might be offered in this field, and of any extension courses in mining or engineering now available under public auspices.

Communication and Transportation.—The communication industries, telephone, telegraph, and radio, have had experience with technical institute men; ratings by these employers in all parts of the country indicate that they like them. While they obtain men trained along mechanical lines from the various technical institutes, by far the largest numbers come from the electrical courses. It is true, also, that electrical courses have been more widely developed in this area of education than have most of the other courses.

A number of the street electric railroads have been using some men from these schools, particularly from the electrical courses, and find them adjustable and useful. The steam railroads have used few to date. Comparatively speaking, they know little about them.

A special effort was made to determine why steam roads have not made wider use of these technical institute men, in view of the types of positions which they have available. It was learned that where they have had experience with them, they have been rated high by the managements and, in several cases, it was found that the companies were sending some of their men annually to one of these technical institutes.

Road and street transportation have attracted very few, while almost none are engaged in water transportation.

Transportation and communication and the railroads hold a wide range of supervisory positions, many of them technical in nature, as well as inspectorships, technicians' positions, etc., which do not require a four-year college training. There are probably not more than 1,500 technical institute graduates now employed in transportation and communication. A study of the types and numbers of positions, together with data from other industries, indicates that transportation and communication have 100,000 positions which could be effectively filled with technical institute men and at the same time not conflict with positions which other forms of education are primarily intended to supply. This would require approximately 3,000 annually for replacement.

Trade.—The percentage of technical institute graduates becoming salesmen is very much smaller than the percentage of college graduates; and the relatively small number who do enter the sales field more often become technical salesmen.

The insurance business is employing some of these men, particularly in its industrial and technical work. Expressions were received from several insurance executives that they like and could use a number of men so trained. It is difficult to make any estimate as to what the potential field for employment is in the insurance business.

The retail merchandising or department store field has used very few from this area of education in the past, but presents a growing market. While in general this is a non-technical business some of the positions therein are requiring more and more technical knowledge; then there are maintenance and management problems of a technical nature for which this type of man might be admirably fitted. This appears to be a potential field of employment for the technical institute man which is new, but which promises not to call for any great numbers.

Public Service.—There are probably a total of 500 technical institute alumni employed in various forms of public service, such as federal, state, county and municipal. The most of these are performing technical services as inspectors, engineers, etc. There is a limited potential field in public service aside from the positions indicated.

Professional Service.—This would include chemists, assayers, metallurgists, designers, draftsmen, inventors, and technical engineers, including civil engineers and surveyors, electrical engineers, mechanical engineers, and mining engineers. Due to the uncertainty as to how many technical institute men are working professionally as such, or are working at these lines in the various industries and counted therein, it is impossible to estimate how many of technical institute graduates are employed under this classification. The number is large; however, it is a question whether in general the technical institute type of training is best adapted to train for professional service. While there are exceptions, it is doubtful whether the largest potential field lies in this direction.

Domestic and Personal Service.—Under this classification, the hotel business requires a certain amount of technical service which might be well supplied by this type of training. The field is rather limited and the number needed would necessarily be small.

The largest field under this heading appears to be the laundry business. One of the technical institutes at the present time is conducting a course for technicians and future executives in the laundry industry. The course appears most successful. In addition, the Laundry Owners' National Association is erecting research laboratories and establishing a technical institute in connection with it, to train future supervisory and administrative forces for the industry. The output from these two sources may be from one to two hundred graduates annually.

Clerical Occupations.—Very few of these alumni are engaged in clerical occupations. Those that are, appear to be largely in technical lines as agents, or engaged in shipping, receiving, etc. No figures are available, but the field for service under this classification is very, very small.

Manufacturing and Mechanical Industries.—Considerably more than fifty per cent of the present alumni of the technical institutes are located in the manufacturing industries.

As previously noted, a number of manufacturing industries have effectively used technical institute graduates in considerable numbers while others have made practically no use of them. An attempt was made to determine why all of the manufacturing industries were not using these graduates. While time did not permit a thorough study to be made in this direction, no definite or tangible reasons were given by those approached beyond the fact that they had not had experience with these men.

In many instances the same types of positions exist in the industries not acquainted with these men as exist in the industries using them. Not only are the positions of the same type but they have similar responsibilities. No reason was advanced why technical institute men might not be as successful in many manufacturing industries which have not learned to know them as with the ones which have.

The particular manufacturing industries which appear to have the smallest per cents of technical institute men in their employ are:

Groups of Industries	Persons Employed (1925 Census)
Lumber and allied products	1,018,961
Food and kindred products	827,544
Paper, printing and related industries	761,826
Railroad repair shops	496,861
Stone, clay and glass products	398,651
Leather and its manufactures	352,801
Rubber products	164,230
Tobacco manufactures	144,863
Musical instruments and phonographs	52,731

This shows a large open field for the employment of technical institute trained men, although some of the industries by virtue of their characteristics would not need so many as others.

Some idea of the potential fields in several of the larger manufacturing industries which have already had considerable experience with this type of trained man is shown in the following table. The requirements are based on earlier studies of the needs.

TABLE III

PRESENT DISTRIBUTION AND REQUIREMENTS FOR TECHNICAL INSTITUTE MEN

Typical Manufacturing Industries	Total Persons Employed	Approximate Technical Institute Graduates Employed	Approximate Total Requirements, Technical Institute Graduates	Approximate Annual Requirements, Technical Institute Graduates
Textiles and their products...	1,627,141	2,000	97,628	2,929
Machinery..................	757,743	4,444	45,465	1,364
Iron and steel and products....	751,270	1,304	45,076	1,352
Transportation equipment....	559,578	716	33,575	1,007
Chemical and allied products..	381,075	276	22,865	686
Total manufacturing.......	9,857,697	10,000	591,462	17,745

Examples of Local Fields Needing Development.—In the main, it has been pointed out that most of the present sources of technical institute education are located in the northeastern section of the country. While this is true, it has also been found that certain sections of this area are served much more intensively than are others. For example, Boston has three or four sources while Philadelphia has only two falling within the specifications of this study. One of these is the Evening Diploma School of Drexel Institute and is available only at night. The other is the Philadelphia Textile School which trains in the technology of textiles and does not meet the needs of other industries. The industries of this section are quite largely diversified as to product, with textiles and their products predominating.

The make-up of these industries is not greatly different from those studied in New Jersey; if we use the ratios of percentages for analysis purposes as obtained in that State the training requirements for Philadelphia may be estimated.

TABLE IV

MANUFACTURING IN PHILADELPHIA NOT INCLUDING CONTIGUOUS DISTRICTS

	(1925 Census) Number of Concerns	Number of Employees
Textiles and their products	1,522	87,109
Paper, printing and related industries	796	23,598
Machinery, not including transportation equipment	356	22,854
Food and kindred products	935	17,940
Leather and its manufactures	143	9,449
Iron and steel and their products, not including machinery	164	8,170
Lumber and allied products	293	7,374
Chemicals and allied products	246	7,346
Miscellaneous industries	387	7,175
Tobacco manufactures	60	6,751
Metal and metal products, other than iron and steel	218	3,548
Stone, clay and glass products	126	2,858
Rubber products	5	485
Musical instruments and phonographs	7	82
All of the manufacturing industries	336	31,084
Total	5,636	246,680

Based upon previously determined ratios the Philadelphia manufacturing industry alone should have in its employ approximately 15,000 technical institute graduates in order to operate in the most effective way, as indicated from other studies. While it is not known how many technical institute graduates may now be distributed in the manufacturing industries of this section it is fairly certain that there are not many more than this number in the entire United States who have graduated from institutions in this country.

On the same basis, the annual replacement requirements in manufacturing for Philadelphia would be about 450. This appears not to be an unreasonable number when it is noted that Boston with about one-third as many employed in manufacture as Philadelphia, probably absorbs that many annually.

This prompted an investigation as to whether there was a saturation point indicated either by the schools or the employers in Boston. The schools indicated no tangible difficulty in placing their graduates; the industries of that section were almost unanimous in their belief that technical institute education should be encouraged and developed.

A determination of just what particular courses are needed for Philadelphia would require a much more detailed study and analysis. All data and analyses indicate quite clearly that the present number of technical institute trained men being produced in Philadelphia annually is inadequate for the needs. While Philadelphia has been used as a typical example, with few exceptions, most of the large industrial cities of the country are no nearer being adequately supplied than is Philadelphia.

It is interesting to note that while there exists a considerable field for development of the technical institute area of education, the Spring Garden Institute there (incorporated in 1854), an endowed institution, is on an actual operating basis only two hours out of twenty-four for about 140 days of the year, or a total of 280 clock-hours a year. At present it operates only as an evening school, covering trade subjects which work does not fall within the scope of this study. When investments aggregating millions of dollars, represented by buildings, equipment, etc., are considered for this and other institutions, operating on a similar time basis, one is impressed, in fact astounded, by the small production or return for the money involved. This comment does not reflect in any way upon the good work already being done in these particular institutions, but rather suggests what might be done, particularly in increased use of the plants and in other types of courses not now available.

When the graduates of the textile schools were being studied it was particularly noticeable that New Jersey has drawn relatively few graduates from the four textile institutes in this country, yet New Jersey ranks high in number of employees in the textile industry. The distribution of the alumni from the Bradford Durfee Textile School, Fall River, Massachusetts, was not readily available for the following tabulation:

TABLE V

Distribution of Technical Men Trained in Textiles

	Lowell Textile Institute	New Bedford Textile School	Philadelphia Textile School	Total	Employees in Textiles and their Product and Textile Machinery	Ratio of Textile School Graduates to Employees in the Industry
Massachusetts	235	151	83	469	226,000	1 to 482
Pennsylvania..	18	5	384	407	214,000	1 to 526
New York....	81	33	243	357	294,000	1 to 824
New Jersey...	22	11	79	112	113,000	1 to 1,009
Rhode Island..	26	39	39	104	78,000	1 to 750

Density of textile school graduates in Massachusetts is 2.1 times the density in New Jersey.

Density of textile school graduates in Pennsylvania is 1.9 times the density in New Jersey.

The geographical area including—

Massachusetts ..	226,000
Rhode Island ...	78,000
Connecticut	56,000
	360,000 textile employees—supports three textile schools.

The geographical area including—

New Jersey	113,000
New York	294,000
	407,000 textile employees—has no immediate supply of technical men trained in textiles.

At least 225,000 and possibly nearer 300,000 of these 407,000 textile employees in New Jersey and New York, are located within a radius of twenty miles from the heart of New York City. Of course, it is true that the character of textile manufacture in this area, particularly in New York City, is different from some of the other areas.

A study of the above tabulation immediately raised the question where the textile area in New Jersey, centering around Paterson and Passaic, was obtaining technical men trained in textiles, if it was obtaining them at all. While the data in this connection were incomplete and in conclusive, they did indicate that this area had originally obtained many of these men from abroad. Restricted immigration has changed this status, and it was indicated that forward looking business men of that section are thinking in terms of a remedy.

This is not intended as a complete analysis of the situation in the textile industry in New Jersey and what might be needed, but as a typical illustration of one area which is served more or less effectively than are others and the suggesting of general possibilities.

It has been noted, too, that the large textile manufacturing area in the South draws relatively few from the textile institutes in proportion to its size. In this section of the country the colleges, particularly the land-grant colleges, have attempted to meet the need. While the most of this work is of recent origin some are disposed to question whether a college is best equipped or can as successfully train in technology of textiles as can textile schools or institutes operated primarily for that purpose.

Present and Desired Status of Trained Men in Employment.—The most extensive analysis was made in manufacture for the reason that technical institute training is better known, along with other forms of training, in that industry than in any other; and, also for the reason that the number engaged in manufacture is between one-fourth and one-fifth of those gainfully employed in the United States. Data offered in this report covered approximately five hundred and fifty thousand manufacturing employees—believed to be a fair sampling. Data from industries other than manufacturing were necessarily drawn from smaller numbers. However, many of them tended to verify or to present the same general characteristics in the way of training needs.

In order to show the magnitude of potential fields for technically trained men the following data are shown:

SUPERVISORY AND TECHNICAL FORCES IN MANUFACTURE

	Approximate Present Status	Approximate Status Desired by Manufacturers
Technical institute graduates	0.8%	46.0%
College graduates	13.0	17.0
From ranks and other training	86.2	37.0
	100.0%	100.0%

It appears that about thirteen per cent of the supervisory and technical forces in manufacture are college graduates, whereas about twenty per cent are college trained, many of them having attended college for various lengths of time without graduating. The manufacturers in the studies of their personnel indicated a desire that for effective operation seventeen per cent of their supervisory and technical forces should be college graduates. At present, three out of four college graduates in manufacture are technically trained, or out of four one is non-technically trained. This means that manufacture should be able to absorb an additional three per cent of technically trained college men, or three men for every hundred now employed. It was also indicated that forty-six per cent of their supervisory and technical forces should be technical institute graduates.

TOTAL FORCES IN MANUFACTURE

	Approximate Present Status	Approximate Status Desired by Manufacturers
Technical institute graduates	0.1%	6.0%
College graduates	1.7	2.2
From ranks and other training	98.2	91.8
	100.0%	100.0%

The above table shows the approximate present and desired per cents of different forms of training in connection with total working forces in manufacture.

Employers say that six per cent of their entire working forces, or a total of about 700,000 men in the manufacturing and mechanical industries, should be technical institute graduates. Were these entirely recruited, as the table indicates they are not, annual replacement would require from 20,000 to 25,000 technical institute graduates for the manufacturing and mechanical industries. Even considering that other industries would not require them in equal numbers, annual requirements of from 40,000 to 50,000 technical institute graduates would appear to be very conservative estimates. In fact, the potential fields for employment of technical institute graduates appear to be limited only by the sources and facilities to train them and the right kind of men to be trained.

V. A STUDY OF TECHNICAL INSTITUTE GRADUATES

The Graduates.—This study of technical institute graduates will attempt to determine some of the contributing influences or circumstances which caused them to attend these schools. In a large majority of cases chance was not the controlling factor.

Many of the graduates had practical experience in industry before attending these institutes; undoubtedly, this prompted a number to seek further training. Oriented to some extent in practical employment, they had formed fairly definite objectives. Time and money were considerations. Some preferred to learn by more direct methods; the greater amount of time spent in shops, laboratories, and drawing rooms appealed to them. Their expressions and reactions on how well they have had their expectations fulfilled since graduation will be instructive.

Because of the limited time and funds for this study of the technical institute area of education, it was impossible to study the graduates of all the schools operating in whole or in part in this field. The sampling process had to be employed. Thus, typical schools of the various types, located in different geographic sections, were selected for a more intensive study of their graduates. In every case the schools cooperated in making contacts with representative numbers of their respective alumni. In the main, the study was confined to the graduating classes of 1894, 1899, 1904, 1905, 1909, 1914, 1919, 1924, 1926, 1927, and 1928.

Definite Objectives.—Many of the men prior to entering these schools had discovered their technical bents, or at least thought they had. Considering all of the schools in this area of education, nearly one-half of the alumni had practical experience in the field of work for which they expected to prepare themselves. Considerably more than one-half of the alumni had experience in some form of employment. These factors have undoubtedly assisted them in forming rather definite objectives.

It is true that a majority of students entering college engineering courses form their decisions to go to college and study engineering at an early date. In the study of college engineering education by the S. P. E. E., it was found that more than three-fourths of the engineering graduates reached a decision to study engineering before graduating from high school, and slightly more than half formed the decision before entering the last year of high school.

The definite objectives of the technical institute men are not pointed so much in the direction of continuing their education along advanced lines as they are in preparing for a particular field of employment, a selected function, or for improvement in their present chosen employment.

A study of 629 graduates from six technical institutes indicated that at the time they entered the institutes, sixty-eight per cent had a specific field of work in mind for which they expected to prepare.

To the question—

> “*When you entered this school, did you have a specific field of work in mind for which you expected to prepare yourself?*”

there were 629 replies, showing the following results:

	Yes
Chicago Technical College (Diploma courses)	94 Per Cent
Westinghouse Technical Night School	83 “ “
Wentworth Institute	78 “ “
Pratt Institute	69 “ “
Bliss Electrical School	60 “ “
Lowell Textile Institute (Diploma courses)	59 “ “
Composite	68 “ “

Westinghouse Technical Night School might be expected to be near the top in definiteness of objective of entering students. This is not so easily explained in other schools, namely, Chicago Technical College and Wentworth Institute. It is equally difficult to explain why Bliss Electrical School and Lowell Textile Institute graduates appear at the foot of the list when they might be expected to be near the top provided the type of course is considered. Of course, it must be remembered that these figures represent the alumni graduated over a considerable period of years and that they may not be truly representative of the present students.

It is significant that approximately seven out of ten graduates had in mind specific fields of work when they entered the technical institutes. There were undoubtedly reasons which influenced, to a greater or less degree, their preferences for specific fields of employment at the time of entrance into the technical institutes. An attempt was made to determine some of these reasons. In a study of 540 of these graduates, thirty-nine per cent gave *special ability for that employment* as the chief reason, and thirty-one per cent indicated *employed at it* as the dominating reason.

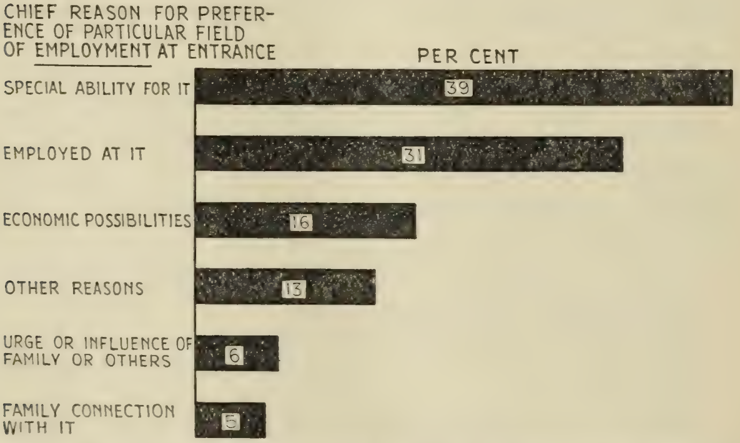


FIG. 6. Chief reason for preference of field of employment at time of entering technical institute

Family influences or ties were major reasons for only eleven per cent. Seventy per cent of these graduates either felt they possessed special ability for that field of employment or were already actually employed at. At some time or another prior to entering the institutes, forty-seven per cent of these men had practical experience in the specific field of work for which they expected to prepare themselves.

Data are presented in this part under two general headings: (*A*) controlling influences and personal reactions of graduates; (*B*) the status of these graduates in business and industry.

A. CONTROLLING INFLUENCES AND PERSONAL REACTIONS OF GRADUATES

Circumstances Which Led up to Attending these Institutes.—The alumni were asked to indicate the circumstances or reasons which led up to their attending the particular school in question. The tabulated replies are shown in the following figure:

Nearness to the home was one of the influences in the selection of a school for three out of eight alumni. This factor affects the present students in about the same ratio. The desire to attend a school in a certain section of the country affects only about one in eight of the present students; the same ratio applies to the alumni.

A decided shift has occurred in the desire of parents to have their sons attend technical institutes; only twenty-one per cent of the alumni were influenced by parents, whereas thirty-five per cent of the present students were so influenced.

Teachers in previous schools appear to have exerted an influence through advice; this has increased from fourteen per cent for the alumni to thirty per cent for the present students. Intelligent advice on the part of teachers in the high schools might spare many boys the embarrassment of failure in college; on the other hand it might start them toward successful careers through a technical institute, and vice versa. To advise intelligently requires a rather intimate knowledge of the characteristics of the various types of education available, as well as the student's predominating abilities. If technical education is to succeed at its best there must be more intelli-

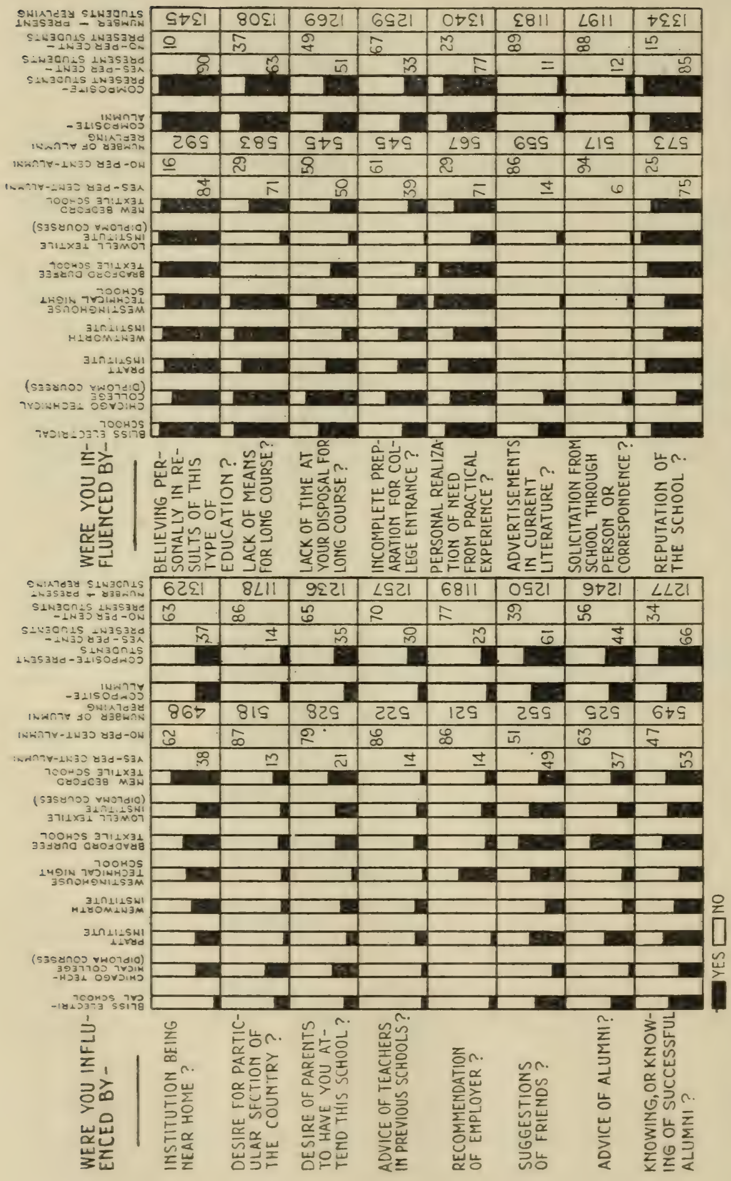


FIG. 7. Circumstances which influenced alumni and present students to attend their respective schools

gent and accurate guidance of students into types of courses where they may be expected to function at their maxima.

The employers advised the present students to a larger degree than they did those who are now graduates. This undoubtedly reflects a pleased attitude on the part of employers.

The suggestions of friends was an influence for one-half of the alumni, and for sixty-one per cent of the present students.

The alumni are in a strategic position to assist the schools in obtaining desirable students; they are also in a position to render valuable service to boys and men needing instruction such as the technical institute offers. An observation in this study is that, in general, the schools which have maintained the closest and most active contact with their alumni appear to be the most successful. Differences in enthusiasm and loyalty of the various alumni groups were quite noticeable throughout the study. It is very apparent that opportunity exists for improvement in the direction of either a better organized alumni or in producing a better pleased alumni. It is interesting to note that advice of alumni had a greater influence on the present students than on previous graduates.

Knowing, or knowing of, successful alumni played an important role in influencing the past graduates in their original selection of a school. Two out of three of the present students were guided to some extent by this factor.

Eighty-four per cent of the alumni said that one of the influences in their decisions to attend the schools which they did was their personal belief in technical institute education; this has risen to ninety per cent for the present students.

Lack of means for a long course did not affect the present students to quite the same extent as it did the alumni. The per cent has dropped from seventy-one to sixty-three. It was rather interesting to note that lack of means was scarcely a factor with the textile institute graduates.

Lack of time at their disposal affected half of the alumni; the present students were affected in approximately the same amount. Lack of time, naturally, may be closely related to lack of means, but the data showed that in many cases lack of time was based upon age. For example, a man thirty years of age, while realizing a need of further technical training, felt he could not at that period in life afford the time to return to school for four years.

Inadequate preparation for college entrance was not so large a factor in reasons for attending schools with more flexible entrance requirements as might have been expected. Sixty-one per cent of the alumni and sixty-seven per cent of the present students had complete preparation for college entrance. Larger per cents were graduates of high school, but lacked certain courses for college entrance. These institutes will probably render the greatest service if they continue to admit students primarily on evidence of their ability to do the prescribed work and along lines of their particular interests, rather than upon formal scholastic credentials.

The personal realization of need of further training from practical experience influenced seventy-one per cent of the graduates and seventy-seven per cent of the present students. ''Promotion depended upon better preparation,'' was a common remark by the graduates. This is true to a greater extent today and probably practical experience may continue to influence a larger per cent during the coming years.

Advertisements in current literature, in general, did not influence the decisions of many of the alumni of the technical institutes as described in this study. It is not uncommon for institutions in all areas of education to advertise their courses. Comments from alumni reflected no criticism of the amount of advertising but did reflect criticism of some types. It is gratifying that the literature, advertisements, etc., of the institutions falling within the scope of this study, with but a few exceptions, were found to follow facts closely and only a very few might be termed misleading.

Solicitation from school through person or correspondence influenced few of the alumni; and while it has doubled for the present students it still remains of minor importance.

The reputation of the school influenced seventy-five per cent of the alumni, a percentage which has increased to eighty-five per cent for the present students. It appears to be an important factor in the decisions of prospective students.

The data in Fig. 7 offer opportunity for greater detailed study and analysis which cannot be given in this brief compass.

Participation in Student Activities.—Technical institute courses are short and intensive. The number of hours per week in school generally exceeds that in the usual college. These conditions, in themselves, may tend to limit the time available for extra-curricular or student activities. Did the alumni when they were in school find any time to devote to such activities? This was answered by 668 from six institutes.

Student Activities	Alumni Having Participated
Athletics	44 Per Cent
Active membership in clubs or societies	36 " "
School or class organization or government	31 " "
School publications	16 " "
Debating or public speaking	6 " "
School dramatics	6 " "
Other activities	6 " "
None	19 " "

Athletics in the technical institutes included very little football, a larger amount of baseball, basketball and considerable tennis, handball, gymnasium activities, etc. Competitive athletics with other institutions played no important part in the school life of the alumni.

Paying Way Through School.—A large proportion of technical institute graduates have had practical experience in the interim between the high school and the institute, frequently a rather extended period. They earned varying amounts in these employments; but even with this assistance seventy-one per cent lacked means for a long course at the time they entered the institutes. It is generally understood that the large majority of technical institute graduates have paid a considerable portion of their way through these schools; the data in the table will show to what extent this was true.

Fifty-three per cent of the alumni of the five institutes tabulated paid more than one-half of their expenses, and forty-

PER CENT OF EXPENSE AT SCHOOL FOR WHICH ALUMNI WERE SELF-SUPPORTING (INCLUDING TRAVEL, TUITION, FEES, ROOM, CLOTHING, BOOKS, ETC.)

Part of Expense	Composite 608 Alumni	Bliss Electrical School	Lowell Textile Institute (Diploma Courses)	Pratt Institute	Wentworth Institute	Westinghouse Technical Night School
0 Per cent.....	*17%*	22%	31%	15%	17%	0%
1– 25 " "	*16*	12	25	21	17	4
26– 50 " "	*14*	9	25	19	23	0
51– 75 " "	*11*	8	6	13	20	7
76–100 " "	*42*	50	13	32	23	89
	100%	100%	100%	100%	100%	100%

two per cent paid more than three-fourths of their total expenses. At the one extreme, the alumni of the Westinghouse Technical Night School paid the largest percentage, ninety-six per cent of them paying more than half of their expenses; at the other extreme, the graduates of the diploma courses of the Lowell Textile Institute paid the least, only eighteen per cent paying more than half, thirty-one per cent paying nothing, and fifty-six per cent paying less than twenty-six per cent of their expenses.

MEANS BY WHICH AND WHEN FINANCIAL SUPPORT WAS OBTAINED BY THOSE WHO PAID OWN EXPENSES IN SCHOOL

	Composite	Bliss Electrical School	Lowell Textile Institute (Diploma Courses)	Pratt Institute	Wentworth Institute	Westinghouse Technical Night School
By work, before entrance to school..................	*32%*	45%	27%	29%	27%	14%
By work, during summer vacations.................	*25*	8	41	34	35	9
By work, during school year	*24*	14	22	20	27	77
Borrowed money which has been repaid or will be repaid...................	*17*	30	10	15	11	0
Dropped out of school for a period to earn money and then returned...........	*2*	3	0	2	0	0
	100	100	100	100	100	100

Since a great majority of these graduates were largely self-supporting, it will be instructive to know the ways in which they secured this support and, if earned, when.

It is interesting to note that relatively few dropped out of school to earn more money to complete their courses. This is what might be expected in the technical institute area of education since most of the full-time courses are not more than two years in length, with the exception of several co-operative courses in which the student is on an earning basis. In general, summer vacations in the technical institute area of education offer small opportunity for earning. The one-year courses naturally have no summer vacations except those immediately preceding the course if the student enters directly from high or other school. Several of the institutes operate the year round. At best, one or two summer vacations are about all that are available. The periods when greatest earnings might be expected are before entrance to school, during summer vacations, and during the school year.

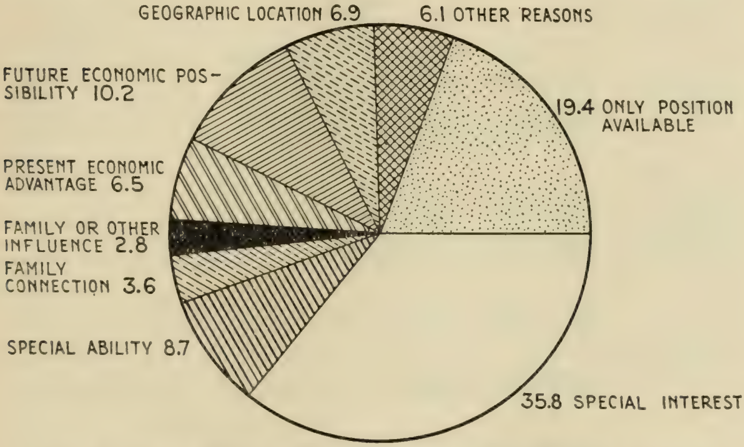


FIG. 8. Main reasons for choice of first position after institute graduation.

Choice of First Position after Institute.—The reasons given by the graduates for choice of first position after graduating from the institutes are shown in Fig. 8:

Special interest evidently exerted more influence than any of the others, it being 35.8 per cent of the total; interest and special ability combined account for 44.5 per cent of the total. The question of present economic advantage, or present salary, appears to have been a very minor factor. It is interesting to note that 80.6 per cent had a fairly free choice of the field or type of employment.

Extent to Which Course Has Met Expectations of Graduates.—The value of a particular type of education may be indicated, at least, by results, and how well expectations of the graduates have been satisfied economically, or socially, or both. The alumni of a representative number of the institutes were asked to express themselves upon the extent to which their courses have met their expectations. Results from typical one and two year courses, together with the composite, are shown.

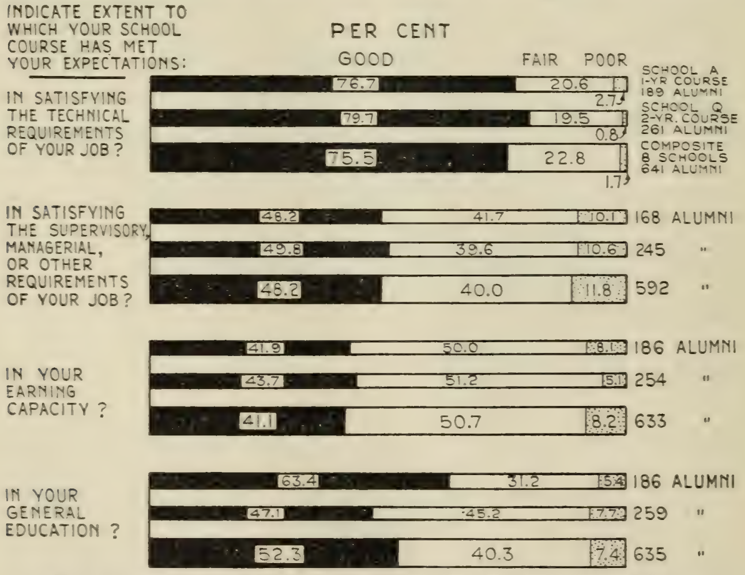


FIG. 9. Extent to which school course has met expectations of graduates.

It is apparent that the training has satisfied the technical requirements of their work. The types and kinds of work in which they are largely employed are shown elsewhere in this report. Those who failed to answer this question were too few to cause any noticeable shift either way in the results.

In indicating the satisfaction with which the supervisory, managerial, or other requirements of their respective positions were filled, the votes are not nearly so conclusive as they were in indicating the satisfying of technical requirements. While only about twelve per cent say that their expectations are poorly met in these requirements of their positions the per cents under *fair* have increased at the expense of those under *good.*

Expectations in earnings have evidently not been met to the satisfaction of the graduates quite as well as technical requirements, and supervisory and managerial requirements. It is interesting to note that in comparison to the immediately preceding question the per cents under *good* have decreased, and at the same time the per cents under *poor* have likewise decreased. The expectations of 50.7 per cent have been met in a *fair* manner as to earnings and 41.1 per cent indicated *good.*

In analyzing the ratings of earning expectations for School "A" in the Fig. 9, it was observed that all graduating classes prior to and including the class of 1919 showed a decided balance in favor of *good* under earning capacity, whereas the balance appears to be in favor of *fair* for all classes since 1919. It is also interesting to note that only one alumnus in graduating classes prior to 1926 checked *poor* under earning capacity.

It is somewhat surprising that 186 one-year course alumni indicated that their course better met their expectations in general education than was indicated by 259 two-year course alumni. Neither the lengths nor the contents of these two curricula would seem to indicate such conclusions.

In general, these courses seem to have met the expectations, in a highly satisfactory way, of the vast majority of those who have graduated from them.

Need or Desire for Further Courses of Study.—It is interesting as well as enlightening to note that about ninety-one per cent of the graduates actually answering this question, or about eighty-two per cent of the total graduates studied, said that they felt the need or desire for further courses of study since graduating from the technical institutes.

Since it is known that relatively few of these graduates have continued their education in full-time schools beyond the institutes from which they have graduated, the question was asked whether they had taken any extension or correspondence courses. Such courses are now available in one form or another almost everywhere, and in nearly every subject.

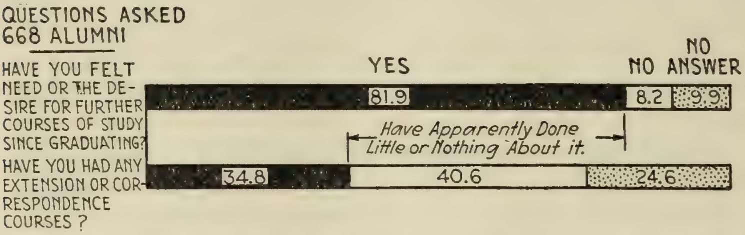


FIG. 10. Need or desire for further courses of study and what has been done.

Replies to this question came from 504 out of a total of 668 alumni, and there was little variation in the ratios of "yes" and "no" from the different institutes.

If this analysis of 668 graduates may be considered representative, it means that 81.9 per cent have felt a need or desire for further courses, but that only 34.8 per cent have realized that desire in any way.

This appropriately raises the important question as to what facilities or opportunities are available for the graduates of the technical institutes to continue their education.

There appear to be four possible paths by which they might accomplish this end.

1. By graduates of the shorter institute courses attending the longer courses in the same area of education.
2. By correspondence courses.
3. By extension classes.
4. By college courses.

The first would open the way for some of the shorter course graduates to continue their education along more advanced lines. Large numbers need not be expected to continue from the shorter courses, yet the institutes adequately equipped to do more advanced work through longer courses might well give consideration to the problem of recruitment into their advanced classes from the shorter course graduates of other schools. This should be particularly true for those shorter course graduates who have shown outstanding ability, and who, for the good of all, should continue their education.

The further development of the cooperative plan, alternating periods at work and in school, laid out along more advanced lines and over longer periods, in the technical institute area offer a possibility worthy of thoughtful consideration. Such arrangements developed on sound educational bases would alleviate, to some extent, financial strain upon the students and at the same time provide outstanding and deserving graduates of the shorter courses with more advanced instruction in the same field of education.

Correspondence courses have their place in the picture. They are especially valuable in supplying certain deficiencies and in what is sometimes termed ''upgrading.'' While it is possible to lay out definite and objective programs of instruction, more advanced than the usual technical institute courses, experience shows that a very few ever carry them to conclusion. This is not intended to detract in any way from the value of correspondence courses, but instead it implies that they may hardly be expected adequately or practically to take the place of more advanced courses in resident institutes where laboratory and shop equipment plays so important a part.

Extension classes are likewise valuable in supplying deficiencies and in ''upgrading.'' Instruction equivalent in point of time to that offered in the first year of the usual resident technical institute is at present available in not more than a dozen extension centers throughout the country and is offered mainly under the auspices of colleges and universities. Most of these extension centers lack the laboratory and shop equipment, and trained and experienced teaching personnel needed for complete and advanced instruction in the technical institute area of education. In addition, extension courses which may be classified at all in this field of education do not exist in more than six states. While extension classes may assist in supplying the need in certain areas, they may hardly be expected to meet the need in general.

A very few have entered the engineering colleges after graduation from the technical institutes. This is not so much due to a lack of college entrance requirements as to other reasons. The institute courses are designed to teach the most useful material in the shortest possible time for rather immediate effectiveness and objectives. Application has been stressed at the expense of some theory. The contents of some of the courses have necessarily had to be abbreviated, but not to the disadvantage of employability for the large majority of positions.

The difficulty has arisen when the technical institute graduates have attempted to enroll in the engineering colleges. The colleges will not contend that the quality of instruction at the institutes, in many cases, has been inferior; on the contrary, in some instances, the practice, laboratory, and shop work are more complete and thorough, and are done with superior equipment than is parallel work in most of the engineering colleges. Thus, the graduates from certain technical institutes experience little difficulty in obtaining credit in the leading engineering colleges for shop and laboratory.

The trouble arises in the ''theoretical'' courses which, by intention, have been different in content. For example, in most cases these technical institute men have neither had the amount nor the kind of mathematics for which the college will allow any considerable credit, regardless of how purposeful or useful the content or how thorough the instruction has been. The college faculty further insists that this mathematics is often neither of an adequate amount nor of the right type to help the student to pursue successfully certain more advanced engineering subjects. These same conditions exist in other branches, aside from mathematics.

For the technical institutes to attempt to shape their programs and curricula toward meeting college credit requirements would definitely defeat their primary purposes and objectives.

As the condition stands, the technical institute graduates could, in the large majority of cases, meet the formal entrance requirements, and would receive credit in varying amounts for laboratory and shop work, but in some of the ''theoretical'' courses would be asked to start very far down the line. What, if any, effect this might have in bringing about a feeling of repetition, waste of time, discouragement, or even embarrassment, would be difficult to estimate. With the college engineering courses as now constituted and with present conditions, it would seem that only in exceptional cases should these technical institute men aim at degrees upon entering the engineering colleges. They should probably be admitted into courses as special students, primarily on evidence of their capacity, with the objectives of continuing, adding to, and broadening their past studies.

Where possible, it would be desirable to have courses laid out specially for this type of man, which would follow more closely aim, method, and content of previous instruction. Unless care is exercised by the college in the layout and administration of such courses, there is danger of a hybrid product resulting from a perfectly good college engineering course and a first class intensive technical terminal course having the earmarks of each and the outstanding qualities of neither. On the other hand, with properly organized courses, administered by those who understand the situation, it would seem to be a desirable move considered from many angles. There are apparent difficulties—administrative, instructional, social, etc. However, the advantages seem to outweigh any disadvantages to such an extent that it is believed experiments in this direction are not only justifiable but desirable.

It is gratifying that one of the foremost and best equipped four-year colleges of engineering in this country has expressed a willingness to discuss such a plan.

Of the possibilities for more advanced study in resident schools by the technical institute graduates, the development of longer post graduate technical institute courses for graduates of the shorter courses, consideration of longer cooperative technical institute courses, and cooperative plans with colleges of engineering, appear the most logical and should receive consideration.

Reasons for Needing Further Courses.—Only 255 graduates from a total of 668 offered specific reasons for needing further courses of study.

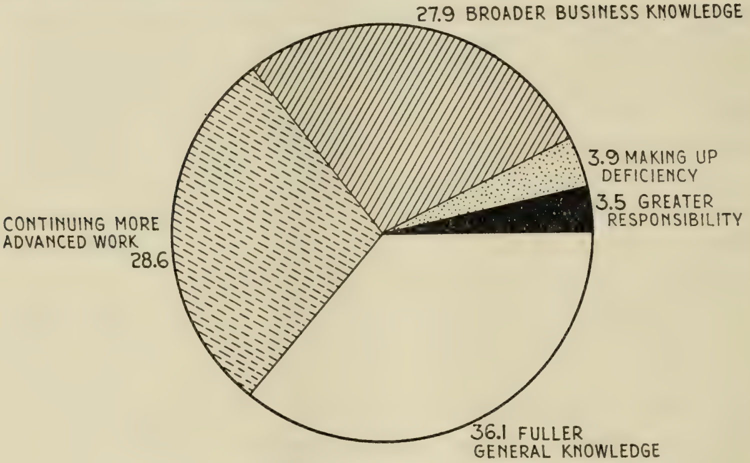


FIG. 11. Reasons for needing further courses.

It is rather surprising to find that of those replying, 36.1 per cent gave "fuller general knowledge" as the reason. This was followed rather closely by "continuing more advanced work," 28.6 per cent, and "broader business knowledge," 27.9 per cent. "Making up deficiency" and "preparation for greater responsibility" were minor reasons compared with the three previous ones. Of course, it is true that the last two reasons may be reflected in the reason, "continuing more advanced work."

How They Attempted to Meet Needs for Further Courses.—Ninety-three named the courses which they were at the time pursuing or had taken since institute graduation. In a number of instances an individual had taken several courses.

Courses	Per Cent
General Business Course	21.5
Public Speaking	12.9
Engineering	10.8
English	10.8
Chemistry	9.7
Sales	9.7
Management and Administration	6.4
Production Methods	4.3
Advertising	4.3
Accounting	3.2
Finance	3.2
Metallurgy	3.2
	100.0

It appears that eleven per cent of these courses were obtained through classes and eighty-nine per cent were obtained through correspondence instruction. Two schools supplied ninety-three per cent of the correspondence instruction.

Modifications Suggested by Graduates.—Figure 12 (*a*) gives the opinions of technical institute graduates on changes and modifications which they feel might profitably be made in the curricula. This figure shows only the composite result which would apply to no particular course since most of the courses are quite different in content and objective. The figure does show in rather graphic form what general subjects

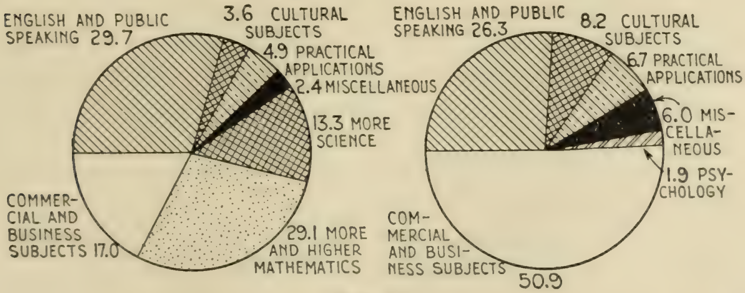


FIG. 12.

(*a*) Subjects suggested by technical institute graduates to be added to courses.

(*b*) Opinions of college graduates as to important omissions from college engineering courses.

might be added, in the opinion of the graduates, provided room could be made for them in already full curricula.

The most significant suggestions were for more and, as some of them expressed it, better instruction in English, and for more and higher mathematics.

The next largest group of subjects for which they expressed a need was in the business or commercial fields. While they expressed opinions for more instruction in these fields, there was no insistence that they be included in the curricula to the exclusion of technical studies. Quite strong suggestions were made for the inclusion of more science—physics, chemistry, etc., and more theory of electricity in most of the courses.

Fig. 12 (*b*) is taken from the study of college engineering graduates and represents the opinions of such graduates as to important omissions in college engineering courses. It is presented here for comparison with the opinions of the technical institute graduates as to their courses.

Many of the technical institute graduates in suggesting modifications appeared to realize that if a new subject were added, or one already in the curriculum were enlarged, some elimination or modification would have to be made. However, a total of twenty-eight individual subjects were suggested to be added and only thirteen suggested to be eliminated. Of course, it was clear that in many cases they did not expect a total elimination but a reduction in time on certain subjects.

Foundry received more votes for elimination than any other subject, followed very closely by pattern-making. Two others close behind were forging and machine shop. Of course, it is understood that these technical institute graduates did not study these last subjects in order to follow these trades, but studied them as material in general technical courses. It is further interesting to note that two out of three of the graduates made suggestions along the line of course improvement.

Would the Graduates Do It Over Again?—A few men graduated from the technical institutes thirty-five years ago. Since then they have been graduating in larger numbers. They have all had experience in life and have associated with men having various types and amounts of training. With the experience of the past, would they do it over again? Reactions of the graduates from typical one- and two-year courses as well as the composite from all the schools studied are shown.

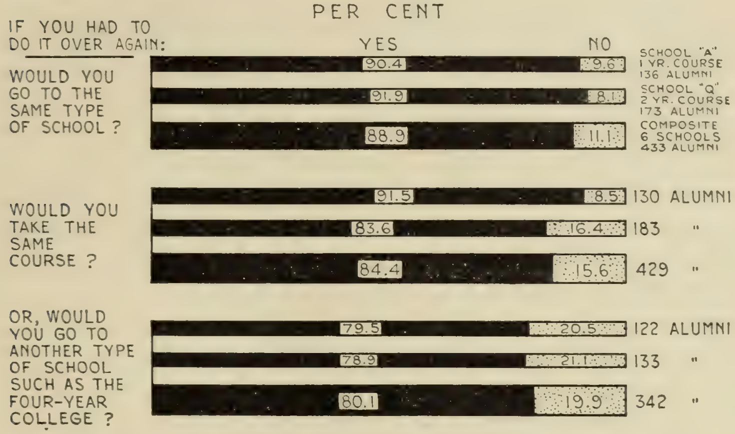


FIG. 13. **Would the graduates do it over again?**

There appears to be a fair unanimity of opinion that they would go to the same *type* of school and would take the same courses. However, the replies to the third question, "Would you go to another type of school such as the four-year college," at first glance appear inconsistent with the replies of the first two. Upon a study of the comments attached to this last question, they are not as contradictory as they may seem. Enough of them, in checking "Yes" under both first and last questions, qualified their answers to make clear their meaning. Their respective schools were sufficiently satisfactory to justify them to go to the same type of school under the *same conditions*. A number did not answer the last question at all. However, the votes and comments indicate that with *different conditions*—better economic status, more time available, etc.—they would have in general preferred longer courses, but not necessarily of a different type such as is offered by the usual four-year college. The methods, contents, and characteristics of technical institute education seem to have justified themselves in the minds of the alumni to a rather remarkable degree.

The Effect of the Absence of a College Degree.—Several of the technical institutes hold charters permitting them to grant degrees, but so far as is known no standard college degrees are actually granted graduates of the shorter intensive courses in what is designated as the technical institute area of education.

It is reported at various times that pressure has been and is being brought by alumni bodies for the granting of college degrees. The conferring of degrees would mean the transformation of the present technical institute education into the usual college form. As a historical fact, this is what has occurred in several instances, but it is believed the alumni were not the dominating factors in these particular transformations.

The following question was asked 668 alumni from six existing technical institutes:

> *"Leaving out of account all purely personal considerations, have you found the absence of a college degree a tangible handicap in obtaining employment, advancement, and recognition by professional and business organizations?"*

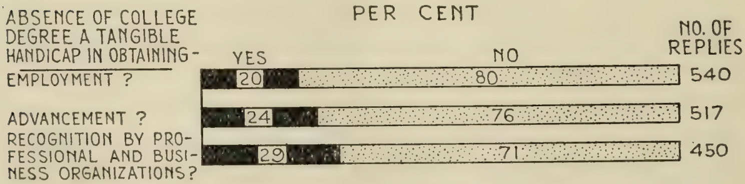


FIG. 14. Effect of absence of college degree.

It is apparent that the absence of a college degree presents no serious handicap to these technical institute graduates. Larger affirmative replies indicating serious handicaps would not have been surprising. In fact, this poll appears significant.

The question of what effect, if any, the absence of a college degree has on the employability of the technical institute graduate, was raised with several leading employment agencies. The trend of opinion appeared to be that for first employment directly after graduation, the absence of a college degree was a noticeable handicap, but that after four or five years' experience it played little or no part in reemployment. Their contention was that, after a period of experience, demonstrated ability to produce results completely overshadowed the absence of a college degree.

There have been some suggestions and attempts to create new degrees for these courses. However, they would mean little or nothing since to be consistent there would have to be a separate degree for each course of different length and type. This would mean scores of different degrees. To attempt to standardize the courses for the sake of degrees, would completely and totally defeat the purpose and objective of technical institute education.

Probably there should be some form of recognition or credentials for this education beyond that which now exists, but it seems clearly not to be in the form of meaningless degrees. The alumni apparently do not strongly reflect such a desire. When such a desire for degrees was manifested among the alumni questioned, it came almost wholly from those recently graduated.

B. THE STATUS OF THESE GRADUATES IN BUSINESS AND INDUSTRY

Types of Positions Held.—During the study, the staff was frequently asked the question, "What types or kinds of positions do the graduates of the technical institutes fill?" This is best answered by showing the positions now held by the graduates of several typical schools. The first to be shown in Table VI are positions held by 1,872 graduates (included in alphabet A to K inclusive) of a one-year electrical engineering course.

TABLE VI

GRADUATES OF A ONE-YEAR ELECTRICAL ENGINEERING COURSE (INCLUDED IN ALPHABET A TO K)

Position	Number of Individuals
Electrician, mechanic, or power plant operator	232
Inspector, estimator, or tester	137
Engineer	104
Proprietor or firm member	87
General foreman or foreman	55
Maintenance or service man	54
Superintendent	45
Salesman	43
General manager, manager, or works manager	42
Non-technical	39
Meterman, lineman, or wireman	33
Chief electrician	31
Draftsman	25
Instructor	25
Erector, installer, or constructor	25
Assistant engineer	24
Sales manager	23
Sales engineer	19
Laboratory worker	17
Clerical	17
Chief Engineer	11
President	10
Chief draftsman or designer	10
Secretary or treasurer	9
Research worker or inventor	8
Patent or legal representative	8
Vice president	7
Technical apprentice	7
Student	7
Purchasing agent	4
Master mechanic	3
Consulting engineer	2
Industrial relations	2
Miscellaneous	233
Names of positions unknown	474
	1,872

The work is dominatingly technical, and it is significant that only two per cent of the alumni from this course are known to be in positions strictly non-technical in character.

The second analysis of positions will be a table showing 370 graduates of a three-year diploma course in textile technology.

TABLE VII

Positions Held by Graduates of Three-year Courses in Textile Technology

Position	No.	Position	No.
Superintendent	50	Electrician, mechanic, or operator	5
Salesman	27	Research worker or inventor	5
General manager, manager, or works manager	25	Chief chemist	5
General foreman or foreman	19	Inspector, estimator, or testor	4
Chief draftsman or designer	19	Purchasing agent	4
Secretary or treasurer	19	Clerical	3
Chemist	17	Time study or rate setting man	2
Proprietor or firm member	15	Draftsman	2
Instructor	9	Laboratory worker	2
Non-technical	7	Miscellaneous	60
President	7	Names of positions unknown	46
Vice president	6		
Engineer	6		
Sales manager	6		370

If numbers in this table are large enough to be representative, about one out of every twelve graduates has a chance to become either a president, vice president, secretary, or treasurer.

The next positions to be shown in Fig. 15 are those held by 3.495 graduates of a school offering two-year courses in industrial chemical engineering, industrial electrical engineering, and industrial mechanical engineering. The range of annual salaries is appended to give some idea of the value of the respective positions enumerated.

It is apparent that approximately half of the graduates of this school, as well as the others cited, are in positions primarily technical in character; this number would be greatly increased were those to be included who are general officers, production supervisory men, etc., in technical industries. Very few from this school, as from the others, are known to be in strictly non-technical positions.

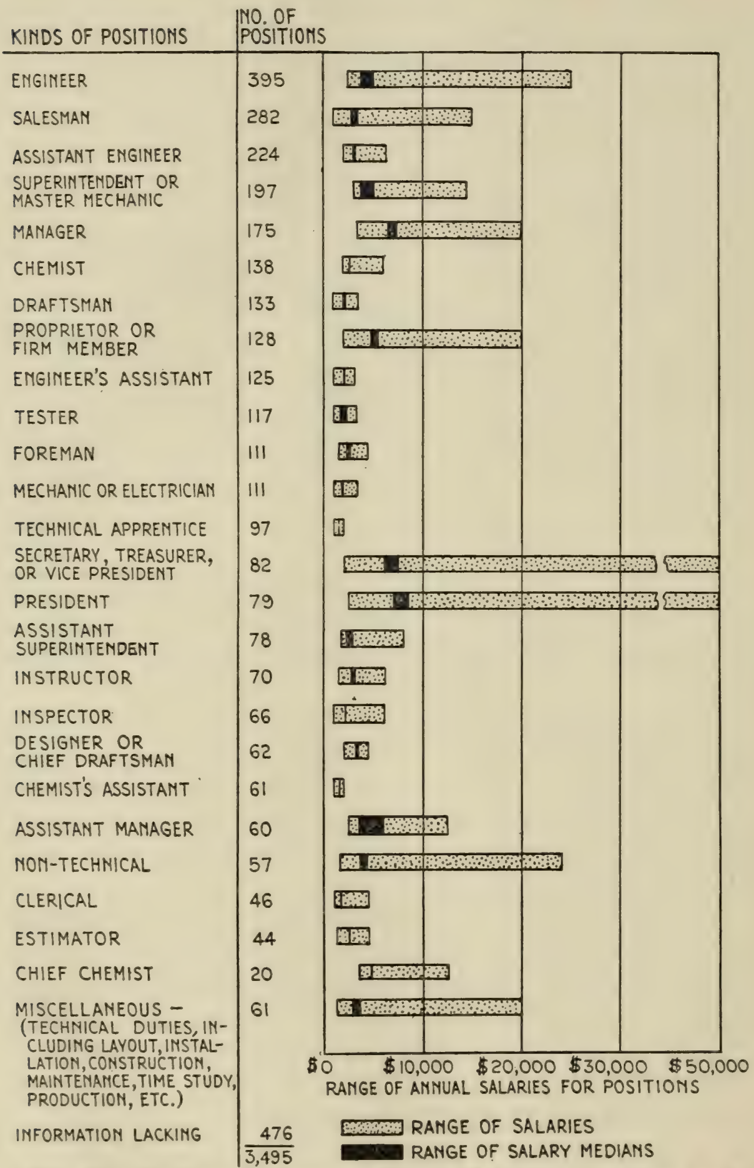


FIG. 15. Positions held by graduates of two-year courses in Industrial Chemical Engineering, Industrial Electrical Engineering, and Industrial Mechanical Engineering.

Earnings of Graduates.—The curves in Figs. 16 and 17 were constructed in each case from annual earning figures supplied by the graduates themselves. Those representing the two-year technical institute courses in each figure include about 1,200 electrical, 1,200 mechanical, and 700 chemical graduates respectively. The curve showing the annual earnings for four-year college engineering graduates * covers 5,023 graduates and is quoted from an earlier study by the S. P. E. E.

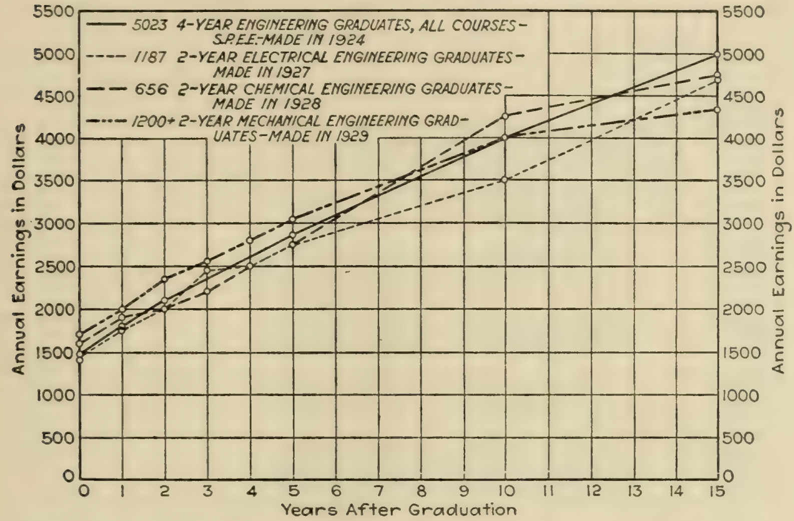


FIG. 16. Comparison of earnings of graduates of two and four-year engineering courses.

The curve for the one-year technical institute electrical course in Fig. 17 represents 165 graduates. The curve of earnings for four-year college electrical engineering graduates was made in 1924 by the Eta Kappa Nu Association † and included 1,118 men of all graduating classes of twenty years or less experience.

---

* Report of the Investigation of Engineering Education, S. P. E. E., Vol. I, p. 233.

† Report of the Investigation of Engineering Education, S. P. E. E., Vol. I, p. 377.

While there were only 165 one-year graduates compared with larger numbers in all other groups, it is doubtful if a larger number of the one-year men would make a great deal of difference in the curve; several tests were made by taking the medians of smaller numbers of these and very little change was noted.

It is surprising that there is no greater difference between the median earnings of the one, two, and four-year courses. The earnings in after years are certainly not in direct proportion to the length of the courses. In this connection, it should be noted that the student graduates from a two-year technical institute course at approximately the same age as the average student who graduates from a four-year engineering college. This means that there has been an interim of practical experience for the technical institute man of from one to two years, usually between high school and the institute. What effect, if any, this period of practical experience, sandwiched between the formal schooling periods, may have on later earning capacity is not known.

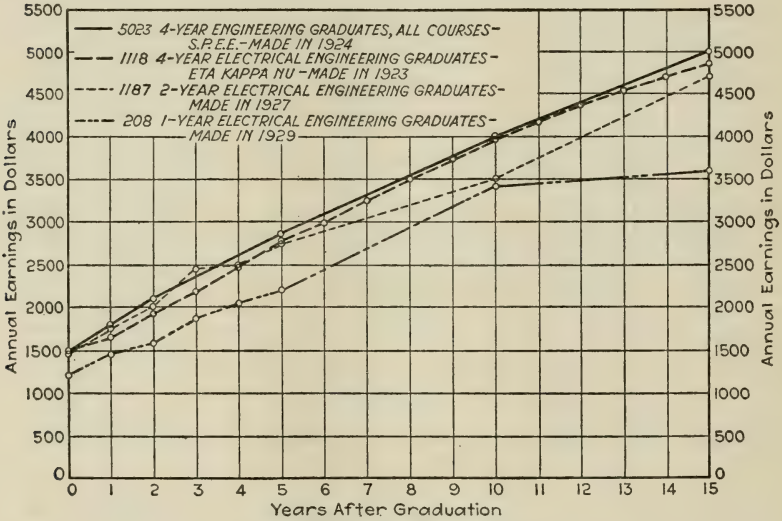


FIG. 17. Comparison of earnings of graduates of one, two, and four-year engineering courses.

Occupations as Related to Course Pursued in Institute.—Figure 18 shows the relationship of fields of work of graduates to courses pursued in the technical institute. It will be noted that 69.8 per cent of the total graduates who supplied data are in the same lines of work as were their institute courses; 17.9 per cent are in closely allied fields; and 12.3 per cent are in fields not closely allied. The composite for college engineering graduates is given for comparison.

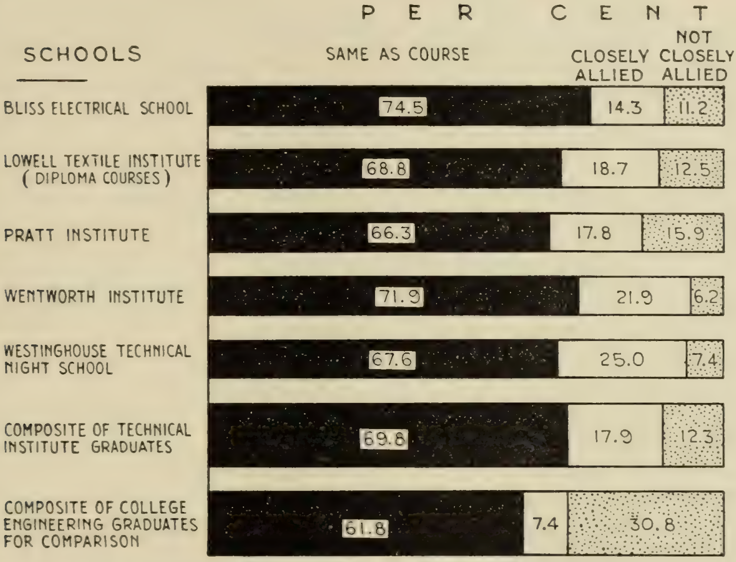


FIG. 18. Relationship of fields of work of graduates to courses.

A study of the fields of work of recent and older graduates indicates that there is a certain amount of drift away from the fields of work directly related to the institute courses, but not more than might be expected. This drift away in later years was found to exist likewise with college engineering graduates.

Paths of Progression in Employment.—The types of positions now being held by technical institute graduates have been shown. It will now be interesting to inquire in what positions they started and what the progression has been to the present time. Are there any positions through which the majority have passed? To study this question, it will probably be best to consider graduates who have been in employment for a considerable period of years. The class of 1909 which has been in employment just twenty years, was arbitrarily selected for an analysis of this question.

The following are samplings from several technical institutes, taking them as they appeared in the alumni lists:

Started, 1909	At Present, 1929
Tester of machines	Farmer
Chief tester	Traffic inspector
Telephone employee	Retail electric merchant
Chemist	Engineer
Instructor	Professor
Calculator	Transformer designer
Laboratory assistant	Owner
Tester	Sales engineer
Draftsman	Chief engineer
Maintenance assistant	Foreman
Draftsman	Instructor of trade apprentices
Helper	Contractor
Operator	Sales manager
Naval electrician	Electrician
Helper	Transmission engineer
Power plant operator	Foreman
Construction foreman	Sanitary engineer
Electrician	Transmission engineer
Plant operator	District manager
Meter assistant	Member of firm
Tester	Gear specialist
Technical apprentice	Assistant general manager
Engineering assistant	Engineer in charge of division
Draftsman	Superintendent
Inspector	Purchasing agent

The above tabulation gave positions in which twenty-five started in 1909, and the positions which they were holding in 1929.

The following will show individual positions in which fifteen 1909 graduates, selected at random from the lists, worked during the past twenty year period. The figures in parentheses denote years spent in the several types of positions.

One-year Course

Started, 1909	Present, 1929
I. Power plant operator (1)	Trouble man (6)
	Chief of maintenance and repair (4)
	Foreman (4)
	Auto control expert (2)
	Foreman (3)
II. Helper (1)	Electrician (6)
	Transmission main foreman (8)
	Superintendent (2)
	Assistant superintendent (1)
	Power transmission engineer (2)
III. Operator (1)	Foreman (2)
	Designer (1)
	Salesman (1)
	Sales manager (15)
IV. Power plant operator (2)	Local superintendent (4)
	General superintendent (12)
	District manager (2)
V. Assistant meter tester (1)	Meter tester (2)
	Inspector (4)
	Estimator (8)
	Member of firm (5)

Two-year Course

I. Tester (1)	Foreman (½)
	Erector (½)
	Engineer (3)
	Sales engineer (15)
II. Calculator (4)	Tester (3)
	Foreman (5)
	Transformer designer (8)
III. Draftsman (5)	Electrical engineer (15)
IV. Draftsman (1)	Chief draftsman (5)
	Production manager (1)
	Detail Engineer (13)
V. Apprentice (1)	Salesman (11)
	Assistant general manager (8)
VI. Laboratory assistant (1)	Laboratory chief (5)
	Development and operation chief (6)
	Assistant to the president (1)
	Owner (7)

VII. Assistant chemist (4)	Assistant chief chemist (2)
	Chemist and metallurgical engineer (2)
	U. S. Army (1½)
	Superintendent (4½)
	Treasurer (2)
	Chemical engineer (4)
VIII. Designer (5)	Designer (2)
	Safety engineer (2)
	Salesman (2)
	Salesman (9)
IX. Draftsman (3)	Designer (7)
	Assistant superintendent (2)
	Superintendent (8)
X. Maintenance assistant (1)	Maintenance man (2)
	Assistant foreman (2)
	Foreman (15)

In analyzing the positions held by fifty technical institute graduates from 1909 to 1929, it is found that more than one-third of these graduates passed through the position of *foreman* at some time during their careers; it is also noted that each man averages about one and one-quarter positions of a very definite supervisory character, such as chief tester, chief chemist, chief draftsman, manager or superintendent. Then, there were a very, very much larger number of quasi-supervisory positions through which they passed. This is cited to emphasize the importance of general supervisory positions in industry and the need for succeeding in them if the higher positions are the objectives.

Shifting of Graduates in Employment.—It has been found that there was considerable shifting from position to position in the early years of the older graduates. For the 1909 graduating classes of three typical institutes, the average man held two and four-tenths positions in the first five-year period, three and four-tenths positions in the first ten years of employment, and four and six-tenths positions from graduation to the present time, or over a period of twenty years.

TABLE VIII

SHIFTING OF OLDER GRADUATES AS TO POSITIONS, EMPLOYERS, AND INDUSTRIES

1909 Graduating Classes. Composite of Three Technical Institutes. 1, 2, 3-Year Courses	Positions			Employers	Industries
	1909–1914 5 Yrs.	1909–1919 10 Yrs.	1909–1929 20 Yrs.	1909–1929 20 Yrs.	1909–1929 20 Yrs.
Maximum changes per man	6	8	9	10	7
Minimum " " "	1	1	1	1	1
Average " " "	2.4	3.4	4.6	3.4	2.6
Average years per place	2.1	2.9	4.4	5.9	7.7

This shows that the average length in years of each position over the twenty year period is more than twice that over the first five year period. A man may have filled more than one position for the same employer which appears to be the case, since for the twenty year period the average number of employers each graduate had was three and four-tenths compared with four and six-tenths individual positions. It is apparent that there has been less shifting from industry to industry than from employer to employer, and still less than from position to position.

The following figure presents an interesting study.

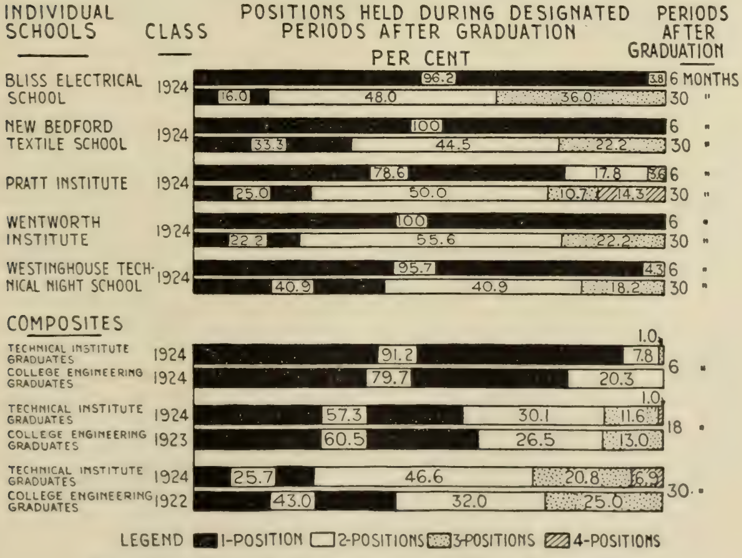


FIG. 19. A study of graduates, shifting in positions.

During the first six-month period after graduation, 91.2 per cent of the technical institute graduates were still in their first positions, while only 79.7 per cent of college engineering graduates were remaining in their first positions at the end of that period. Eighteen months after graduation, 60.5 per cent of college engineering graduates were yet in their first positions, compared with 57.3 per cent of technical institute men. At the end of thirty months of employment, only 25.7 per cent of the original technical institute men were in their first positions while 43 per cent of the college engineering graduates were still in their first employments.

What Employers Think These Graduates Can Best Do.—In another part of this report, it was stated that fifteen countrywide industries having experience with technical institute graduates were approached for their reactions concerning them. One of the questions asked this group of companies was:

> *"What, if any, outstanding or noticeable traits, attitudes, or types of adaptability in general to graduates of this type of education have?"*

The majority of those replying to this question indicate as worthy of note the following, arranged in relative order of importance:

1. That they are adaptable to supervisory and foremanship positions and advancement in operating departments. (Adaptability)
2. That they are adaptable to plant operation and maintenance. (Adaptability)
3. That they have ability to get on with workmen. (Trait)
4. That they are adaptable to technical services, such as drafting, detailed designing, editing specifications, laboratory testing, technical inspection, etc. (Adaptability)

5. That they have ability to do teamwork with associates (Trait)
6. That they have ability to cooperate with executives. (Trait)
7. That they are adaptable to construction and erection in the field. (Adaptability)
8. That they show willingness to accept plant hours and conditions of work. (Attitude)
9. That they are adaptable to technical sales work. (Adaptability)

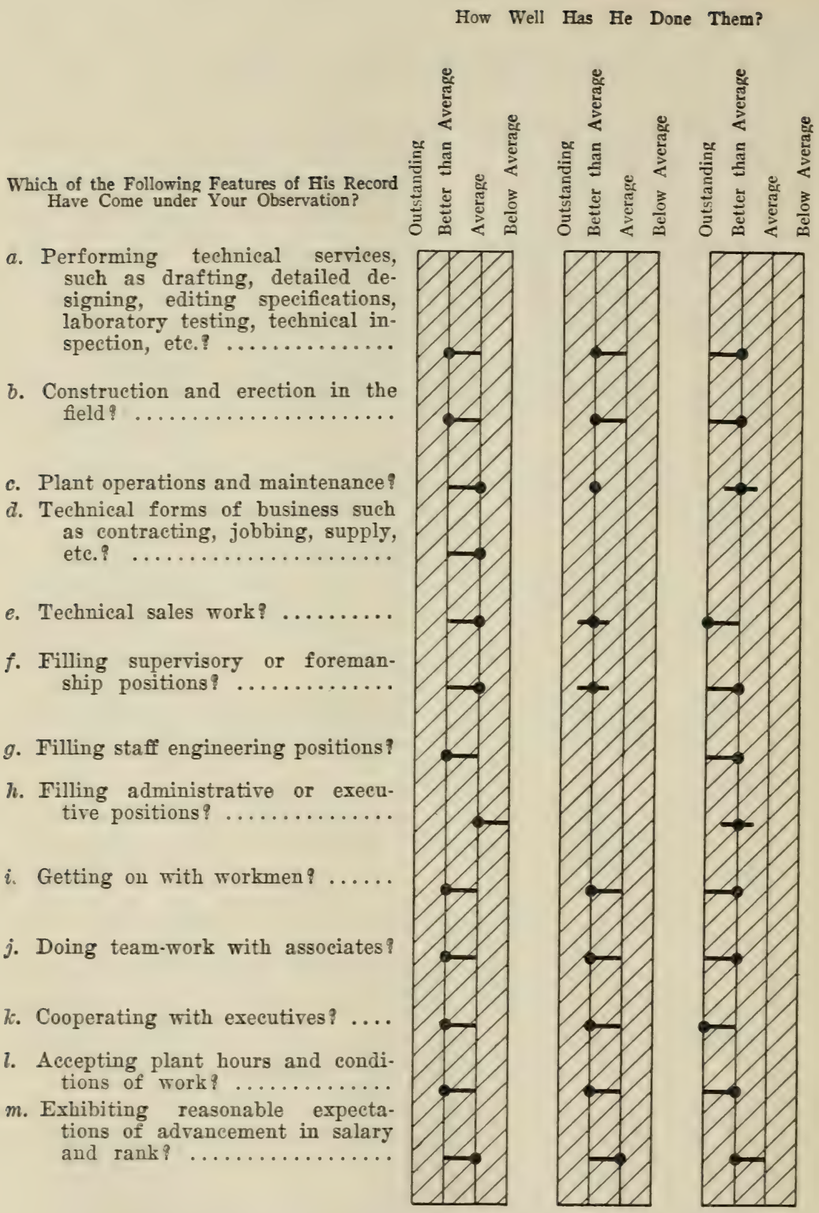
The opinions of those answering were equally divided between ''Yes'' and ''No'' on the following items:

10. Adaptability to administrative or executive positions. (Adaptability)
11. Adaptability to technical forms of business, such as contracting. (Adaptability)

The opinions of those answering were distinctly negative in connection with the following items, continued to be arranged in relative order of importance:

12. Adaptability to staff engineering positions. (Adaptability)
13. Reasonable expectations of advancement in salary and rank. (Attitude)

How Well Do These Graduates Actually Function in Industry?—In order to obtain a more concrete and definite evaluation of how well these men actually function, rating sheets were prepared and sent to the known employers of a number of the alumni. These employers were asked to have superiors in rank to the graduates, whose names were submitted, fill out and sign the rating sheets. It was further requested that the superiors doing this confidential rating should be intimately familiar with the work of the graduate and be in a position to supply such information fairly and without prejudice. Cooperation on the part of the employers



	School "A". 1-Year Course	School "U". 2-Year Course	School "Q". 2-Year Course
Number of individual graduates rated	124	23	44
Number of individuals rating graduates	92	23	38

FIG. 20. Summary of ratings of the graduate of three typical technical institutes by their superiors in industry.

was excellent, many of them expressing appreciation for this opportunity to check up themselves on the effectiveness of these employees. The results of these ratings are summarized in the following figure.

The dots indicate the largest number of ratings for a particular question; the lines are drawn from the dots representing the largest ratings toward the second largest ratings. Where lines are drawn both ways from a dot, it indicates that the numbers of ratings on both sides of the dot were equal.

VI. TYPICAL STUDIES OF OCCUPATIONAL RESPONSIBILITIES AS AN AID IN CURRICULUM BUILDING

The Curriculum—An Important Problem of the Institutes.—The subject, indicated by the title, is discussed by reason of its direct connection with a problem which is uppermost in the minds of those responsible for the administration of these technical institutes.

At the beginning of the study, the institutions in the United States, operating in whole or in part in this particular area of education, were invited to submit problems to be considered. Many were presented, but the one which appeared most frequently had to do with the content of the curriculum. That is, whether the right subject matter, in the correct proportional amounts, extending over proper periods of time, for maximum effectiveness, is being taught. These items are of far greater significance in the building of a shorter terminal-point curriculum of one or two years in length, than in a longer curriculum of four years. In the former, time very definitely dominates the situation. There is only time available to give instruction in essentials thought to be necessary to attain certain predetermined objectives.

The shorter the course the more rigid must be the schedule of studies. There is little opportunity for the student to substitute subjects or choose electives. The curriculum offered is expected to be the one best and quickest path to a particular objective; and its construction requires experience and skill which the student necessarily lacks. The terminal character of these courses is another reason why it is necessary to be exacting, inclusive, and careful in the laying out of the curriculum. As the course becomes more definite in purpose or objectively vocational, the more inflexible must be the curriculum.

In view of the influence which certain factors—such as content, time available, course length, terminal character, definiteness of purpose—exert upon the curriculum and the graduates, the prospective student has a right to expect the best course of study which can be devised for a particular objective, or objectives.

A few believe that they have solved these curriculum questions in a manner satisfactory to themselves through systematic study and experimentation; but a solution in one case may not answer in all cases. In this area of education, for every school which has solved its curriculum problems satisfactorily to all concerned, there are five which have not. It is difficult to say off-hand what is included in a curriculum which may be non-essential, and what is not included which may be essential. Several institutions in this area have been eminently successful in attaining desired objectives; the majority have reached a fair degree of success, while a few are groping aimlessly. Many of the uncertainties which exist may be attributed in part to the relatively brief period in which most of these institutions have operated; there are few graduates prior to 1900, the growth having occurred since the war period.

No Clearing House Available for Information and Data.—Another factor is the absence of any organized channel in this particular area of educational activity for the exchange of data, information, and the study of mutual problems. Regardless of diversity of type, form, or objective of these institutions, there do exist many common problems.

No collective experiences as to methods of curricula building or information as to the most effective course content for particular objectives are available. Collectively, and many times individually, consideration has not been given to teaching methods and curricula content when admittedly this type of education is more practical in content, more specific in aim, and more direct in method than the usual instruction of the engineering colleges.

Significant experiments are being conducted by individual schools, and only incidentally do others in the same field hear of them and the results or conclusions coming therefrom.

Aids in Curriculum Building.—A definite objective kept clearly in mind is probably the first requisite for success. Whether the objective is to train men for the supervision of industrial production, installation, operation, the operative technology of specific industries or for certain groups of positions, the content of the curriculum is a most important factor in meeting particular industrial requirements for technically trained men.

The more usual methods or mechanics of curricula building are well known, as are also the weaknesses of these. Someone's hunch or the extraordinary sales ability or influence of a department head should play a small part in the original formulation or in the constant revision of a technical institute curriculum. A more accurate and scientific method than is ordinarily followed should be available. This is particularly true where the curriculum depends so largely upon content, allocation of time, and, most important, seeing that every minute counts.

Beginnings have been made in more scientifically planning and building curricula. These experiments were suggested by practice in industry. Study of the duties and responsibilities of jobs, and the writing of specifications incident to a more intelligent selection and placement of employees, are common practices in industry. In fact, there are few employment departments in industry which do not use job specifications in some form. The analyses of jobs and the responsibilities determined therefrom have been of practical value not only in the selection and replacement of employees, but also in training in and for industry. This training covers a wide variety of objectives, including apprenticeship and training for better foremanship.

The realization in business and industry, during the past decade, of the definite need of better trained supervisory forces and leaders has necessitated analyses and studies of the duties of men who supervise and direct other men in order that the training might be made more direct and effective.

In a large per cent of the 933 * foremanship courses given in

---

* See Fig. 3, p. 67.

1927, some attempt was made to analyze the responsibilities of the men enrolled. The first objective was to interest the man in his job and its possibilities; another was to assist in arranging the content of the course or conference for a more direct usefulness. While, of course, this is a different area of education from the one under study, results justify very serious consideration of the possibilities for the use of so-called job analysis in building more effective programs of studies in the technical institute field.

Job analysis has been made use of as an aid in the organization of a curriculum for the training of printing executives at the Carnegie Institute of Technology. It has, likewise, been used in studying the curriculum for pharmacists. A significant experiment is now in progress in the technical institute area of education and the results deserve watching. The Rochester Mechanics Institute is revising curricula through the aid of job analysis. It is not more than reasonable to expect that a school may more effectively and efficiently strike at its goal if it knows the duties and responsibilities which the graduates meet in actual practice. A study of the relative importance, or in some cases the relative frequency of occurrence, of each responsibility is a further practical aid in determining where and upon what emphasis should be placed in the training process. This means an accurate knowledge of the responsibilities of the positions, either vertical or horizontal, which the graduates of the institutions ordinarily occupy in attaining the objective, or beyond, such as the case may be.

Analyses of Typical Positions in Industry.—A study of present employments of the alumni of a number of the technical institutes shows that a very large percentage from every institution have either passed through or are at present in supervisory positions in industry. The supervisory positions claiming the largest numbers are superintendent, assistant superintendent, foreman, chief electrician, chief inspector, chief draftsman, etc.

Typical analyses of supervisory positions are shown, with

TABLE IX

Relative Order of Importance of Groups of Responsibilities Based on Sum of Ratings

Responsibilities having to do with:	225 Foremen	35 Sup'ts	35 Asst. Sup'ts	2 Chief Electricians	9 Chief Draftsmen	7 Draftsmen	6 Junior Draftsmen
(I) Working force	44.9%	28.8%	22.3%	34.3%	30.6%	8.4%	1.1
(V) Methods	20.5	35.3	39.6	31.4	30.6	28.4	9.9
(VI) Management	11.9	8.2	4.4	4.4	6.4	7.3	2.2
(IV) Production (Goods in process)	8.9	5.8	11.6	10.9	12.3	53.7	82.4
(III) Materials and supplies	6.9	8.8	7.1	5.1	7.3	1.1	4.4
(II) Machinery and equipment	6.5	8.0	11.1	8.8	7.7	1.1	0.0
(VII) Specialized technical phases	0.4	5.1	3.9	5.1	5.1	0.0	0.0
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE X

Relative Order of Importance of Groups of Responsibilities Based on Frequency of Occurrence

Responsibilities having to do with:	225 Foremen	35 Sup'ts	35 Asst. Sup'ts	2 Chief Elec-tricians	9 Chief Drafts-men	7 Drafts-men	6 Junior Drafts-men
(I) Working force	44.8%	28.1%	23.2%	33.3%	31.0%	12.5%	3.3%
(V) Methods	20.7	41.2	42.9	33.3	31.0	28.1	10.0
(VI) Management	11.0	8.1	3.4	4.8	7.1	9.4	3.3
(IV) Production (Goods in process)	7.9	5.2	10.4	9.5	10.7	43.8	76.7
(III) Materials and supplies	7.6	6.1	7.0	4.8	7.1	3.1	6.7
(II) Machinery and equipment	7.4	7.5	9.7	9.5	8.3	3.1	0.0
(VII) Specialized technical phases	0.6	3.8	3.4	4.8	4.8	0.0	0.0
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Whether the relative order of importance of groups of responsibilities is based on Sum of Ratings (Table IX) or on Frequency of Occurrence (Table X) makes little difference in the final tabulation, yet that based on Sum of Ratings (Table IX) is preferred as the more reliable.

Noting Table IX, the characteristics of the positions of foreman, superintendent, assistant superintendent, chief electrician, and chief draftsman are in general the same although the intensities of groups of responsibilities vary to some extent.

164 of the analyses were obtained through cooperation of the American Council on Education.

150 of the analyses were obtained through cooperation of the U. S. Chamber of Commerce.

75 of the analyses were obtained by the S. P. E. E. with the active cooperation of the Western Electric Company and the Westinghouse Electric & Manufacturing Company.

emphasis placed on that of the foreman or equivalent position, regardingless of title. Technical, supervisory, and administrative positions in industry have not yet been studied and analyzed to nearly the same degree and extent as have work jobs. This is not because they are considered less important, but because of lack of time and also because of the fact that work jobs have been easier to study.

In these analyses, it was early observed that identical responsibilities appeared in the work of a large per cent of the foremen studied, regardless of types and kinds of business and industry represented. That is, aside from fundamental knowledge of the industry, the responsibilities of a rubber factory foreman are very largely common with those of a steel mill foreman; in fact, the duties of the foreman are largely common with those of other supervisory positions, particularly those just listed.

Here, it will be interesting to study Tables IX and X.

Will Knowing Responsibilities Aid in Curriculum Development?—Advancement in employment is usually based on how well responsibilities are performed. It was stated earlier that large numbers of these technical institute graduates, at some time or other during their employment careers, occupy supervisory positions. From Table IX, it is observed that, aside from general knowledge of the industry in which employed, nearly one-half of the foreman's, approximately one-fourth of the superintendent's and assistant superintendent's, and about one-third of the chief electrician's and chief draftsman's responsibilities have to do with the ''working force.'' These actual working responsibilities encountered in practice may have had some part in crystallizing the opinions of technical institute and engineering college graduates as to suggested additions or omissions from the courses studied by them,—and shown on page 104.

Is this significant for curriculum building? Possibly not, from the standpoint of the inclusion or exclusion of certain subjects. Perhaps, emphasis should be placed on certain phases of these responsibilities included in studies already in the curriculum, or possibly some of the phases might better be emphasized and developed along extra-curricular lines. Some may contend that little can be taught as to how to deal with ''working force'' responsibilities, or that scientific data dealing with personnel problems are not available for teaching purposes. Nevertheless, the fact remains that the supervisory positions in industry have many important responsibilities dealing directly with the working force. Beyond question, advancement depends, to a considerable degree, upon performance.

The institutions whose graduates are primarily trained for, or pass through, the supervisory positions in industry might well review from time to time what they are doing either in the formal curriculum or outside of it to prepare their graduates to cope more successfully with ''working force'' responsibilities.

Another important group of responsibilities in Table IX has to do with ''methods.'' This group, in general, is more tangible in character than the group having to do with the ''working force,'' and thus is more susceptible to curriculum adjustment.

It may be surprising to note the relative unimportance of the responsibilities having to do with ''specialized technical phases'' in Table XI. Of course, it is understood that the person in a supervisory position should possess fundamental knowledge of the industry or the type of work over which he presides. Therefore, the term ''specialized technical phases'' refers more particularly to responsibilities usually belonging to staffs, maintained for that purpose, such as the research, chemical, or engineering departments.

It is often considered that the positions of superintendent, assistant superintendent, and foreman are line positions and in direct sequence. An examination of Table IX and Fig. 21 shows that the superintendent and foreman occupy line positions, but it also reveals that the superintendent's responsibilities are more nearly like those of the foreman than are those of the assistant superintendent. Were there a direct sequence, the "working force" responsibilities of the assistant superintendent would be greater than the same responsibilities of the superintendent, yet less than those of the foreman. On the other hand, the "production" responsibilities of the assistant superintendent would be less than those of the superintendent, and greater than those of the foreman. In fact, the work of the assistant superintendent has the earmarks of a staff position instead of a pure line position. On the other hand a direct line sequence is shown in Fig. 22 where certain responsibilities of chief draftsman, draftsman, and junior draftsman are charted.

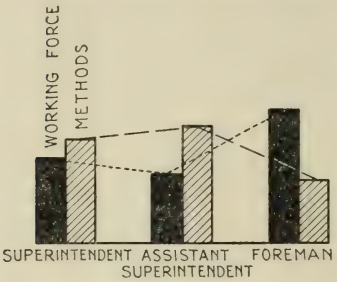


FIG. 21. Responsibilities.

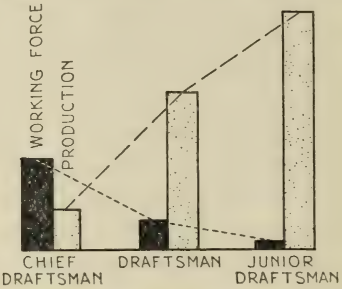


FIG. 22. Responsibilities.

The foremen represented in this analysis came from a wide variety of industries and well distributed as to size of companies. In order to determine whether the point of stability in the relative order of responsibilities had been reached, 70 additional analyss, rated according to "frequency of occurrence," were combined with the original 225 shown in Tables IX and X, with results as shown in Table XI.

Summary of Observations on the Use of Occupational Responsibilities in Developing or Revising Curricula.— The foregoing positions for which the responsibilities have been assembled are representative ones in present-day business and industry. They are the typical positions in which large numbers of technical institute graduates find themselves at some time or another during their lives. They are, also, positions through which the technical institutes themselves expect many of their graduates to pass.

TABLE XI

RELATIVE ORDER OF GROUPS OF RESPONSIBILITIES OF THE FOREMAN'S POSITION

Responsibilities have to do with:	225 Foremen, Based on Sum of Ratings	225 Foremen, Based on Frequency of Occurrence	295 Foremen, Based on Frequency of Occurrence
Working force	44.9%	44.8%	44.8%
Methods	20.5	20.7	20.7
Management	11.9	11.0	10.9
Production (Goods in process)	8.9	7.9	7.9
Materials and supplies	6.9	7.6	7.6
Machinery and equipment	6.5	7.4	7.5
Specialized technical phases	0.4	0.6	0.6
	100.0%	100.0%	100.0%

It is a reasonable assumption that a more definite knowledge of the responsibilities of positions occupied should materially aid in developing training programs.

There appears to be but one way to find the responsibilities of a particular position, and that is by studying or analyzing the position and thus determining that position's specifications.

In order to be effectively useful the relative order of importance of the responsibility elements of a position should be reflected in the "job analysis." A common characteristic of many "job analyses" is a mere listing of responsibilities with no, or little, attention to relative importance. The American Council on Education, Washington, D. C., has in its files intended for educational use probably the largest number of records of performances or analyses of industrial positions in existence. Even many of these lack quantitative assignments in the order of importance.

The *frequency of occurrence* of a responsibility appearing in the analyses of a number of like positions may be used as a measure of its relative importance. However, it is possible that a responsibility may appear in a large per cent of analyses of like positions yet be relatively unimportant. This possible condition was checked in the connection with the positions of

TABLE XII

LIST OF RESPONSIBILITIES APPEARING IN ANALYSES OF 225 FOREMEN'S POSITIONS ARRANGED IN RELATIVE ORDER OF IMPORTANCE BASED ON SUM OF RATINGS

Relative order	Group in table IX		Sum of Ratings
1.	(I)	See after safety of workers	1702
2.	(I)	Instruct and train workers	1496
3.	(I)	Supervise workers	1435
4.	(I)	Cooperate	1362
5.	(I)	Give and distribute orders	1359
6.	(VI)	Keep down costs	1314
7.	(V)	Plan and lay out work	1303
8.	(VI)	Prevent waste	1173
9.	(IV)	Maintain quality of production	1121
10.	(II)	See that workers have proper tools	1107
11.	(II)	Maintain and repair machinery and equipment.	1100
12.	(I)	Study and know men	1070
13.	(I)	Maintain discipline	1033
14.	(I)	Arouse interest in work	1026
15.	(IV)	Maintain quantity of production	1020
16.	(I)	Look after working conditions	1000
17.	(III)	Requisition materials	993
18.	(I)	Encourage loyalty	973
19.	(V)	Maintain good "housekeeping"	945
20.	(VI)	Carry out orders	932
21.	(I)	Assign workers to jobs	928
22.	(I)	Create goodwill and morale	875
23.	(V)	Know details of job	853
24.	(V)	Make reports—general	837
25.	(III)	Keep right amount of material on hand	834
26.	(IV)	Get work out on time	824
27.	(I)	See after welfare of workers	783
28.	(V)	Take lead in work	773
29.	(V)	Recommend progressive methods	738
30.	(I)	Obtain confidence of men	738
31.	(I)	Maintain attendance	700
32.	(V)	Make decisions	698
33.	(V)	Keep records	697
34.	(I)	Be agreeable and pleasant	651
35.	(IV)	Process and fabricate materials	644
36.	(I)	Recommend discharges	620
37.	(I)	Reduce labor turnover	618
38.	(V)	Schedule work	613
39.	(IV)	Inspect or check work	611
40.	(V)	Locate and correct mistakes	611
41.	(I)	Keep time records of workers	590
42.	(VI)	Interpret policies to workers	588
43.	(I)	Recommend promotions	571
44.	(I)	Train apprentices	564
45.	(IV)	Care for rush orders	564
46.	(I)	Adjust complaints and differences	547
47.	(I)	Render first aid	546
48.	(I)	Maintain number of workers	536
49.	(III)	Handle and store materials	520
50.	(V)	Observe conditions	517
51.	(V)	Report on costs	485
52.	(I)	Recommend transfers	477
53.	(I)	Interview or hire workers	476
54.	(III)	Requisition and keep supplies	471
55.	(I)	Recommend demotions	464
56.	(VI)	Answer correspondence	456
57.	(VI)	Approve and check time cards	456
58.	(V)	Report on production	437
59.	(III)	Distribute materials	436
60.	(V)	Make estimates	434
61.	(V)	Make investigations	430
62.	(III)	Receive and inspect material	430
63.	(VI)	Attend conferences	419
64.	(II)	Study and recommend changes	408
65.	(VI)	Advise as to attitudes of workers	396
66.	(VI)	Assist in setting rate of pay	385
67.	(V)	Report on tests	384
68.	(I)	Introduce new workers	363
69.	(II)	Keep up buildings and premises	353
70.	(I)	Note outside personal habits of men	337
71.	(II)	Recommend new machinery and equipment	302
72.	(V)	Report on shop labor	290
73.	(VI)	Meet customers	247
74.	(II)	Improvise machinery and equipment	238
75.	(VII)	Specialized technical phases	225
76.	(VI)	Meet salesmen	29

TABLE XIII

FIRST 25 RESPONSIBILITIES ARRANGED IN RELATIVE ORDER OF IMPORTANCE BASED ON SUM OF RATINGS

35 Superintendents	9 Chief Draftsmen
1. (I) Supervise workers.*	1. (I) Supervise workers.*
2. (V) Plan and lay out work.*	2. (V) Plan and lay out work.*
3. (V) Make reports—general.	3. (I) Cooperate.*
4. (VII) Specialized technical phases.*	4. (V) Observe conditions.*
5. (V) Observe conditions.*	5. (I) Assign workers to jobs.*
6. (I) Assign workers to jobs.*	6. (V) Know details of job.
7. (V) Keep records.	7. (VII) Specialized technical phases.*
8. (I) Cooperate.*	8. (VI) Carry out orders.*
9. (II) Maintain and repair machinery and equipment.	9. (II) Recommend new machinery and equipment.
10. (I) Interview and hire workers.	10. (IV) Process and fabricate material.
11. (I) Instruct and train workers.	11. (III) Keep right amount of material on hand.
12. (IV) Inspect or check work.*	12. (IV) Get work out on time.
13. (V) Recommend progressive methods.	13. (II) Study and recommend changes.
14. (III) Requisition material.*	14. (III) Requisition material.*
15. (III) Handle and store material.	15. (IV) Inspect or check work.*
16. (V) Report on production.	16. (IV) Maintain quality of production.*
17. (V) Make decisions.*	17. (I) Give and distribute orders.*
18. (V) Make investigations.*	18. (V) Make decisions.*
19. (III) Requisition and keep supplies.	19. (V) Schedule work.*
20. (VI) Meet salesmen.	20. (III) Receive and inspect material.
21. (V) Report on costs.	21. (V) Make investigations.*
22. (VI) Carry out orders.*	22. (II) Improve machinery and equipment.
23. (IV) Maintain quality of production.*	23. (IV) Care for rush orders.
24. (V) Schedule work.*	24. (VI) Answer correspondence.
25. (I) Give and distribute orders.*	25. (VI) Prevent waste.

* Indicates responsibility common to both positions analyzed above. A count shows 14 common responsibilities out of the first 25 listed.

foreman, superintendent, assistant superintendent, junior draftsman, chief draftsman, and chief electrician. The relative order of responsibilities based on *sum of ratings* and *frequency of occurrence* of the responsibilities, as noted in Tables IX, X and XI, did not reflect any considerable divergencies. The relative order of importance based on the *sum of ratings* of particular responsibilities in like positions appears preferable, yet in the absence of these the *frequency of occurrence* may be sufficiently accurate for general purposes.

The relative order of importance of groups of responsibilities based on either *sum of ratings* or on *frequency of occurrence* indicated quite clearly that the characteristics and responsibilitities of supervisory positions in business and industry are remarkably similar regardless of names of positions or of types of industry.

Those schools which have as one of their major objectives the training for supervisory positions in any or many lines of industry might profit from a study of the typical supervisory positions analyzed in this report, or by the study of other supervisory positions into or through which their respective graduates may go; it is known that a large percentage of graduates of all the technical institutes studied for this report have in the past or are now occupying such supervisory positions.

Only two "work" positions—junior draftsman and draftsman—were studied, and these with the purpose of showing the cleavage of responsibilities compared with a supervisory position such as chief draftsman.

Considering that the American Council on Education has been assembling thousands of records of performance or job analyses and that the Rochester Mechanics Institute and Athenaeum is at present using job analysis extensively in revising its curricula and courses, it was believed appropriate to discuss briefly this division of work and present typical illustrations.

If so-called job analysis is a practical and effective tool for educational development, and particularly for the development of curricula, no area of education would appear to offer a more auspicious setting for its use than does that of the technical institute. The experiments referred to, at least, deserve thoughtful consideration.

In order to revise or build new curricula probably the first essential step is to determine or clarify the objectives; the second step is to select the content of the curricula to attain those objectives, but before the latter can be best done considrable must be known concerning what responsibilities the graduates will inevitably be called upon to meet in practice.

VII. THE TECHNICAL INSTITUTE AS A GOING CONCERN

A. General Conspectus

Summary of Salient Points.—Two tables are adjoined which summarize a group of salient facts covering a representative group of six day schools offering full-time and cooperative courses and group of five evening and extension schools. Taking all the institutions studied into account, a selected group of facts may serve to give a composite view of the situation. With this in view, field notes based on visits to a considerable group of schools have been edited into a series of brief characterizations.

Bliss Electrical School.—An outstanding example of a one-year monotechnic school, financially self-sustaining, representing an intensive development covering 36 years. Charges cover all costs, have amortized building debt, extended equipment and earned a substantial reserve. Moral character and personal appearance stressed in admitting students. School advertises in a dignified manner. Has capacity enrollment drawn from wide area. Student group serious-minded, attentive to work, and gentlemanly. Although every item of procedure is carefully pre-arranged, teachers do not appear repressed or hampered. Cooperation with alumni stressed. Mr. Bliss visits ten or twelve cities for alumni reunions every year and every five years holds alumni reunion at the school, providing free entertainment. Also invites groups of high school principals and industrial officers to be guests of the school and advise on its work.

Bradley Polytechnic Institute.—As originally organized all its courses were within the field of the study; these are now pushed to one side and are attended by a handful of vocational teachers and special students. The teachers of vocational subjects are desirous of developing strong courses of the

Full-Time and Cooperative Institutes

	Bliss Electrical School	Chicago Technical College	Ohio Mechanics Institute	Pratt Institute	Rochester Mechanics Institute	Wentworth Institute
Names of courses	Electrical engineering	Architectural; building construction; civil, electrical and mechanical engineering	Industrial, electrical, mechanical, and industrial engineering; cooperative power laundry course	Industrial, mechanical, electrical, and chemical engineering	Cooperative electrical, mechanical, chemical	Machine construction; electrical construction; power plant; architectural construction; foundry
Length in years	1	2	2	2	3	2
Weeks' attendance per year	32	36	36 (engineering) 21 (2) (laundry)	36	19.	36
Hours' attendance per week	35	36	32½	30		30
Hours' home-work per week	15	20	12 to 15	21		15
Entrance requirements:						
Minimum age	18	16	None	None	None	18
Education	Grammar school † experience; high school preferred	Grammar school; 2 years high school preferred	4 years of high school	4 years of high school except for mature entrants	4 years of high school or equivalent	4 years of high school
Industrial experience	Not required but preferred	Not required but preferred	Not required but preferred	Flexible, at least 1 year preferred	None	Not required; 1 to 3 years preferred
Enrollment, February, 1928	340	232	78	448	327	282
Graduates, 1927–28	316	41	22	180	52	119
Students dropped, 1927–28	15	25	27	9 per cent	56	41
Tuition per year	$800*	$290	$100	$159	$135	$100
Cost of instruction per student	$400	$275	$300	$400	$423	$400
Plant and equipment provided	Earnings	Rental and earnings	Gifts	Gifts	Gifts	Gifts

* Includes board. † Also equal period in practice.

EVENING TECHNICAL INSTITUTES AND EXTENSION SCHOOLS

	Cleveland Y-Tech.	Newark Technical School	Westinghouse Technical School	Rutgers University Extension	Penn State College Extension
Names of courses	Mechanical, electrical, structural, and chemical junior college	Civil, architectural, mechanical, electrical, automotive, and chemical engineering	Engineering	Essentials of mechanical engineering	Engineering
Length in years	3	4	4	3	3
Weeks' attendance per year	40	28	32	24 to 26	24
Hours' attendance per week	9	10 to 13	9	5	5
Hours' home-work per week	12	4	9	5	5
Entrance requirements:					
Minimum age	None	16	None	18	None
Education	High school	High school or special preparatory course	2 years high school minimum	1 year algebra and science or equivalent	8th grade
Industrial experience	No definite requirement; average 3 years	None required; 3 years preferred	None required; students are employees	None required	None required; 1 or more preferred
Enrollment, February, 1928	(1)	1440	272	104	592
Graduates, 1927–28	4(1)	100	32	7*	95
Students dropped, 1927–28	46	260	82	8*	121
Tuition per year	$126	$60	$52	$40–$45	$30
Cost of instruction per student	....	$80	$58	$60–$67	$44.40
Plant and equipment provided	Gifts and earnings	Public and gifts	Rental, earnings and gifts	State	State

* Course newly established.

technical institute type, but the administration is "strong" for "full college work."

The Horological School, an autonomous department with its own building, is a flourishing monotechnic institution and a pioneer in its field in the Unted States. It enrolls 90 students from all parts of America and some from abroad, and has accommodations for 125. Its length of service (since 1886), mainly under one man, and its close tie-up with the industry, give it a unique place in its field.

Chicago Technical College.—A proprietary institution, State-chartered, with degree-granting privileges. Advertises extensively. Enjoys confidence of local engineering organization. The strong personality of the President is an important factor in its success. Cannot afford to discriminate closely in admitting students. Program very diverse; includes degree courses and correspondence courses as well as those in field of study. Objectives seem not well defined; program possibly too diverse for best efficiency. Students admitted at any time. Many members of faculty on part-time; all have non-teaching experience; many have written special class-room manuals for own work.

Cleveland Y. M. C. A. Junior Engineering College.—An evening school, associated with a cooperative day engineering school granting degrees, constituting about 5 per cent of the total program. Industries encourage this work. Uses same equipment as day school. Many of staff on part-time. "Cred its" given seem very high in proportion to time requirements. Fees relatively high considering equipment and teaching costs. Typical example of Y. M. C. A. work observed in field of study; others, Lincoln Institute of Boston; evening division at Detroit, down-town college at Chicago, and New Haven College.

Dunwoodie Industrial Institute.—Distinctive in methods of admission and instruction; admits students at any time, permits them to remain one or more months at will to leave and return at any time and to extend their studies over an indefinite period. All instruction strictly individual. Was included in field of survey on account of published courses of study. Visit revealed no evidence that materials of instruction were other than trade practices and methods. The Director speaks much of training for the ''non-coms'' of industry. No replies to questionnaires received.

International Correspondence Schools.—The only institution visited which offers correspondence instruction primarily. Number of graduates in the technical institute area probably exceeds that of any resident school, about equally divided between civil, electrical and mechanical engineering. Average age of graduation about thirty-two. Graduates in demand for personal qualities; instruction not assumed to be superior to that given by a resident school. Practically all graduates previously employed for a long period. Instruction and service, both for students and graduates, found to be well organized and efficiently administered. President states aims thus:

> ''Our greatest service to industry is in bringing up a man through the ranks where he is employed. Our first aim is to assist men with initiative to qualify for advancement, and usually this can be accomplished most effectively with the confidence of the employer and by coöperating with him in solving his training problems. Our close relations with employers would not be cordial if we promised other positions to students. The student grows up in the industry as a rule and is not transplanted to some other industry.''

Lowell Institute Evening School.—The courses are of the engineering type, taught by members of the faculty of the Massachusetts Institute of Technology in its laboratories and from the viewpoint of the engineer of scientific qualities. The Director claims that within their limits, the courses are equal to the day courses at M. I. T. The school is not akin to others in the survey in personnel, aims, content of courses and methods of instruction. Admissions highly selective and strictly limited. Doing a splendid work for a limited group of men, so placed in industry that they can carry a heavy load of outside preparation. Could be copied in very few centers. Very fragmentary data supplied.

Lowell Textile Institute.—Gives 4-year degree courses and 3-year non-degree courses, with strong engineering bias. Shorter courses being displaced; 85 per cent of students in degree courses. Differences on paper between 3-year and 4-year courses less apparent on inspection. One teacher remarked that the 4-year course is simply longer. No social or academic distinctions between the degree and non-degree students. Director claims industry much prefers four-year men. Has unit evening courses and special adult day courses. Large plant, admirably equipped.

Milwaukee School of Engineering.—Owned by a stock company. Advertising methods somewhat criticized locally. Courses under survey comprise 60 per cent of school program. Also has degree courses. Has correspondence courses and conducts classes in Montreal, Canada. All courses arranged in well-defined units; students may enter at any time and proggress at individual pace. Equipment organized in units paralleling text material. Appearances indicate meagre financial support and resources. Director a serious student of teaching problems.

New Bedford Textile School.—This and kindred school at Fall River train expert operators who have a fair knowledge of technical processes and are potential supervisors, superintendents, managers, etc. Both were privately founded, but now under control of the State. Both have local committees of administration. Evening courses are principal part of the program, e.g., New Bedford had 92 day and 1550 evening students. Materials of instruction are all very *specific,* all general studies being eliminated. Shows signs of inbreeding and possible need of new life and a larger vision of community needs.

Ohio Mechanics Institute.—Old institution, well financed and well equipped. High school and special courses enroll over two-thirds of the students. Stresses teaching of fundamental mathematics and science. Policy to meet local situation; not otherwise clearly defined. Two-year engineering courses feel competition of cooperative courses at the University of Cincinnati; there is some talk of changing them to a 3-year cooperative basis. The cooperative power laundry course is unique of its kind.

Pratt Institute.—Endowed institution, conducted as a family enterprise. Has distinct schools of Science and Technology, Household Arts, Fine and Applied Arts and Library Science, with day and evening divisions. Equipment chosen for its specific needs, but equal in amount and character to high-grade engineering colleges. Same true of faculty. Day courses of a strictly engineering character. Policy well-defined and closely followed. Admission selective; capacity limited, always fully occupied. Requires evidences of "employability" as well as high school preparation in mathematics, science and English. Courses train for both technical and supervisory positions. Laboratory teaching especially well developed. Most successful example of 2-year day engineering school.

Rhode Island School of Design.—Began in 1879, part of city art and library center. Offers a 3-year course in Mechanical Drawing and Design; both day and evening divisions. In 1927–28 there were 33 day and 166 evening students. Teaching is done by two men. Only class work in mathematics, otherwise teaching is highly individual. Entrance requirements low and very flexible. Place within field of study doubtful.

Rochester Athenaeum and Mechanics Institute.—An endowed civic institution. Principal exemplar in field of study of the cooperative method. Authorities very reticent about their work and policies. Have a special committee working on curriculum revision, using job analysis techniques. Present courses instituted in 1923 and 1926. Local in its appeal to high school graduates.

Rutgers University and Pennsylvania State College, Extension Divisions.—Administrative personnel young and not widely experienced in teaching. Viewpoint that of a "business" to be promoted and expanded, with secondary regard for educational policies or standards of admission, vocational selection, guidance, etc. Teachers in off-campus centers are part-time men without training in methods of teaching and lacking time to plan and prepare in an adequate manner the detail materials and projects of instruction. Doing a useful work, valuable as supplement to other agencies but might retard efficient state-wide programs if left free to develop the field alone.

Richmond (Va.) Mechanics Institute.—Founded in 1854. Has excellent new building. Operates evening school only, with total enrollment of 800. Present equipment inadequate for extended technical institute work. Faculty, excepting Superintendent, all part time. Time usage of plant low—280 clock-hours per year, as contrasted with nearly 3000 hours in certain urban institutions with day and evening sessions.

Wentworth Institute.—Well endowed and finely equipped school of industry and trades. Draws almost wholly from New England, and for most part direct from high schools. Faculty strong and well selected. Aims well defined, courses not based on college models. Resources used to capacity.

Westinghouse Technical Evening School.—Sustained by Westinghouse Electrical and Manufacturing Company as part of its educational program in cooperation with the public educational authorities of the district. Teaching is done mostly by the younger employees of the Company, supplemented by a few mature and high-salaried men. More advanced faculty limits attention to problems of content and method in teaching; offset in considerable part by the maturity and industrial backgrounds of students, and by the high character of supervision.

B. STUDENTS AND STUDENT LIFE

Sources.—Data supplied by three representative day schools indicate that close to 70 per cent of their students are drawn from the families of industrial and business owners and employees, about 12 per cent from farms and about 18 per cent from the families of professional men and brain workers in general. More complete data on students entering the engineering colleges show approximately 52 per cent from the first, 17 per cent from the second and 31 per cent from the third of these respective groups. No data were gathered on the origins of evening students but the proportions from industrial and business groups are almost certainly higher and those from professional and brain-work groups less.

Preparatory Education.—The technical institutes, as a rule, do not insist upon graduation from a 4-year high school as their basis of admission but consider evidences of purpose, maturity and capacity to do the required work. The proportion of high school graduates runs high, however, in the more efficient day schools, less in the established evening schools, and low in the extension evening schools. In the one evening extension school studied the percentage of high school graduates enrolled was 36.

PERCENTAGE OF HIGH SCHOOL GRADUATES ENROLLED

	Maximum	Median	Minimum
8 representative day institutes	95	73.5	46
5 representative evening institutes	87	66	51

The preparation of students is much more variable than in the colleges. At Bliss Electrical School, for example, 6 per cent of an entering class had never studied algebra and 5 per cent had had five semesters of the subject; 13 per cent had never studied plane geometry and 64 per cent had spent two semesters on it; 42 per cent had had no chemistry and 45 per cent two semesters of chemistry. Pratt Institute reports that 18 per cent of an entering class had had no physics, but that 60 per cent had had two semesters or more of chemistry. A majority of those admitted have had no shop-work in the high school, Bliss reporting 61 per cent, Pratt 58 per cent and Wentworth 58 per cent without this type of preparation. Naturally, the methods of teaching must be kept flexible to deal with groups of so varied a character, however admirable their selection from a vocational point of view.

Ages of Students.—The median age of students enrolled in technical institutes is apparently higher than among college undergraduates. It is lower, however, in the day institutes than in the evening schools—20 years and 7 months in the former and 22 years and 10 months in the latter. In the one evening extension school covered on this item the median age

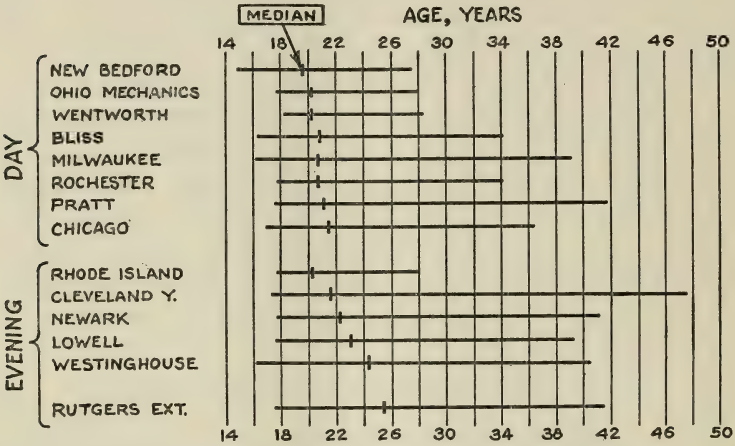


FIG. 23. Range of ages of students in technical institutes.

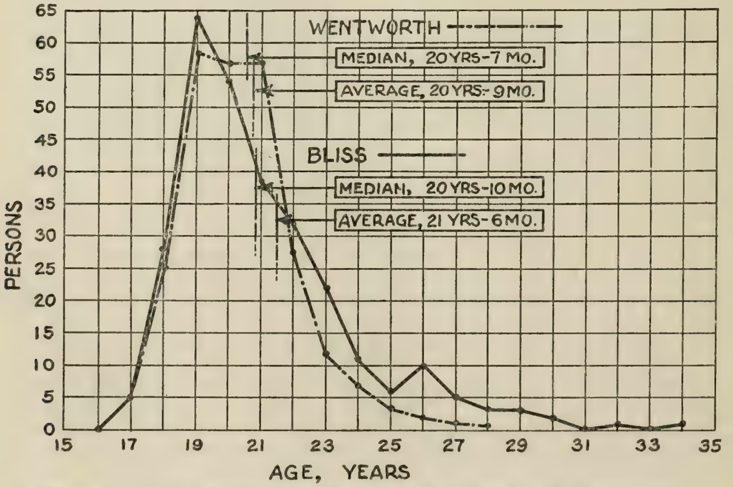


FIG. 24. Age distribution of students at Bliss and Wentworth.

was 25 years and 2 months. The complete age ranges are shown in the accompanying diagram.

The diagram gives evidence of a considerable enrollment of mature men in both day and evening institutes. Most of these students would be wholly out of place in a junior college and ill-adjusted in the environment of the usual four-year engineering college.

Previous Industrial Experience.—While few technical institutes make industrial experience before entrance a specific requirement, nearly all prefer it and the percentage of students who have been employed in a normal, full-time manner is usually fairly high:

PERCENTAGES OF STUDENTS WITH FULL-TIME INDUSTRIAL EXPERIENCE

	Maximum	Median	Minimum
8 representative day institutes	89	78.5	43
5 representative evening institutes	93	87	53

In the one evening extension system for which data were supplied, 91 per cent of the students had been previously employed. Among those employed the percentages who had engaged in farming were fairly small; industrial experience strongly predominated. While 90 per cent of the students admitted to engineering colleges have previously worked in some capacity, much of it has been in vacation periods and in fairly casual capacities. The occurrence of normal full-time experience is decidedly lower in the college group.

Aims of Students and Influences in the Choice of School and Course.—Information supplied by alumni indicates that fully two-thirds of the students who enter technical institutes have some specific field of work in view, and that their choices are based chiefly on special ability (39 per cent), being employed in it (31 per cent), economic possibilities (16 per cent), and family or personal influences (11 per cent). The observation of those best informed, supported by fairly definite evidence,* is that the aims of college students of engineering are much more general and their understanding of their prospective fields more vague.

Evidence gathered from nearly 1350 students and 600 alumni of a group of eight representative institutes makes it clear that certain well defined influences govern the choice of a school and of a course of study:

INFLUENCES WHICH GOVERN THE CHOICE OF SCHOOL AND COURSE

	Alumni		Present Students	
	Yes, Per cent	No, Per cent	Yes, Per cent	No, Per cent
Believing personally in this type of education	84	16	90	10
Reputation of the particular school	75	25	85	15
Personal realization of need from practical experience	71	29	77	23
Lack of means for a long course of study	71	29	63	37
Knowing or knowing of successful alumni	53	47	66	34
Suggestions of friends	49	51	61	39
Lack of time for a long course	50	50	51	49
Institution being near home	38	62	37	63
Advice of alumni	37	63	44	56
Incomplete preparation for college entrance	39	61	33	67
Desire of parents	21	79	35	65
Advice of teachers in previous schools	14	86	30	70
Recommendation of employer	14	86	23	77
Desire for a particular section of the country	13	87	14	86
Advertisements of the school	14	86	11	89
Solicitation by person or correspondence	6	94	12	88

The most significant inference, it seems, is that so large a proportion deliberately decide to seek further education and choose a school by its reputation and a program of work suited to their time and means. Personal guidance by parents and others is apparently a minor, though growing, factor. Data gathered from students in eight additional institutions corroborate these findings quite consistenly.

Self-Support.†—All the endowed and private day institutes provide scholarship aid a limited number of worthy students and assist some by loans or by employment. One evening institute (Lowell) charges only a registration fee of $5.00. Only one other of the evening group has scholarships and few of them. The giving of scholarship aid is generally regarded as unnecessary for evening and cooperative students, practically all of whom are employed and earning amounts in excess of their school expenses.

---

* See Report, Investigation of Engineering Education, S. P. E. E., Vol. I, p. 192.

† See also page 95.

The proportion of day students who pay a considerable part of their own way is fairly striking, as shown in the accompanying figures:

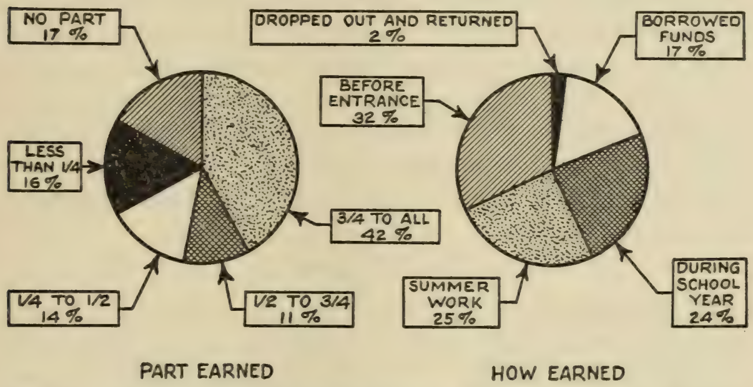


FIG. 25. Extent and means of self-support among students in technical institutes.

This large measure of self-support doubtless accounts in a measure for the independence shown by students in the choice of schools and courses and contributes to the nature and serious spirit manifested in all the student bodies.

Student Life and Activities.—Only one institution, the Bliss Electrical School, has its own dormitories and a required residential system. The close contacts of this internal regime tie students and alumni to the school in a unique manner. Most of the technical institutes, including many working on an evening basis only, cultivate an active student life through athletics, clubs, social functions, and the like, though on a less elaborate scale than that prevailing in the colleges. Participation in these activities appears to be quite general; 44 per cent of all the students replying specify athletics, 36 per cent clubs and societies, 31 per cent school or class organizations, and 16 per cent publications, while only 19 per cent give no indication of any extra-curricular activity.

General Observation.—The facts set forth above, supplemented by direct observation, make it plain that the technical institutes are serving a group of young men fairly distinct from those who can or do attend the engineering colleges; a group equally worthy and if anything superior in definiteness and seriousness of purpose. The loafer and sporting types are fairly unknown. Students' initiative in the learning process is relatively high, especially where practical performance is concerned. The proportion of students of high cultural backgrounds is visibly lower than in many of the colleges. The whole situation tends to draw and develop men of action and practical resourcefulness rather than men of high reflective and analytical powers.

C. TEACHERS

Educational Qualifications.—The ten institutions which supplied data make up a representative group, as do the 239 individuals represented. It is evident that formal academic qualifications are not the primary criterion in selecting teachers nor in determining their status and advancement. In none of the ten institutions are all the teachers in the field covered by this study graduates of high schools, as shown by the following range:

PERCENTAGE OF TEACHERS WHO ARE GRADUATES OF HIGH SCHOOLS, BY INSTITUTIONS

Maximum	Median	Minimum
93.3	80.6	68.7

In this particular the technical institutes afford a striking contrast to the publicly controlled high schools and junior colleges which operate on a closed-shop basis with college degrees and credits in education serving in lieu of a union card.

It is striking, however, that every teacher has had some training of a post-secondary or adult character. Taking the ten institutions collectively, 70 per cent of their teachers hold college degrees. In two of the ten all teachers have degrees, though neither would be ranked by the staff as first in efficiency. On the other hand, one of the most efficient schools has but two teachers with degrees out of a total of 14, the others having been trained by the school itself.

While the advanced training of the teachers is not of a sterotyped character the amount averages fairly high; 71 per cent have had at least four years beyond high school and 18 per cent have taken university graduate work ranging in extent from one to four years. Only 5.4 per cent have taken all their post-secondary work in evening schools. Among the 239 persons reporting in all, 4 hold the degree of Ph.D., 1 that of Sc.D., 39 the master's degree and 45 professional degrees in engineering. In evaluating these data allowance must be made for the inclusion of a considerable group of teachers of manual arts, chosen more largely for their experience and proficiency than for academic qualifications of any kind.

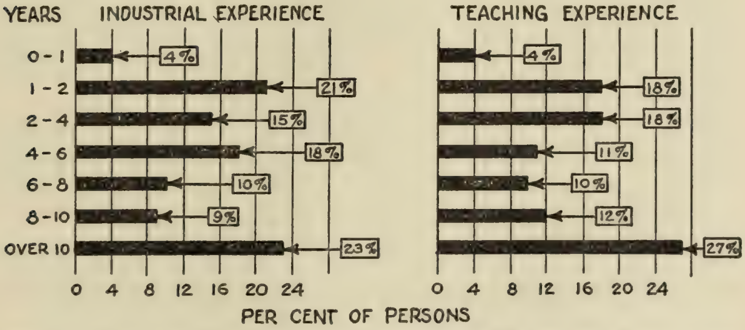


FIG. 26. Teaching and industrial experience of teachers in technical institutes.

Age and Experience.—While a large measure of flexibility prevails in the academic qualifications of teachers, in the matter of non-teaching experience the conditions are strikingly uniform, as only 9 persons or about 4 per cent of the entire group had not had experience of this character before entering teaching. The extent of this industrial experience ranges from 1 to 35 years. The median period is about 5 years. The higher figures occur in evening schools, e.g., Newark and Westinghouse, which employ as evening teachers principally men engaged by day in industrial pursuits. Chicago Technical College, Milwaukee and the Cleveland Y. M. C. A. also use largely part-time teachers in active industrial practice. In the other instances full-time teachers predominate or are used exclusively.

As the data on experience clearly indicate, most of the teachers are men of moderate maturity. The age data confirm this inference.

AGE GROUP OF TEACHERS

Below 30	27 per cent
30–35	22 " "
35–40	19 " "
40–45	13 " "
45–50	8 " "
Over 50	11 " "

The median age by schools runs as follows: Bliss, 35; Chicago, 34; Cleveland Y., 35; Milwaukee, 30; Newark, 33; New Bedford, 42; Pratt, 32; Rochester, 32; Wentworth, 41; Westinghouse, 31.

Sources of Recruitment.—Of the twelve heads of schools who supplied information, seven report no trouble in securing properly qualified instructors, two report limited difficulties, two considerable difficulty and one is non-committal. The two who meet with difficulty are both heads of full-time schools of distinctive character. Their comments are, respectively:

> "It is more difficult than securing them for engineering college teaching."
>
> "No source of ready-qualified teachers exists. Neither ex-college teachers nor mature men from industry are satisfactory."

The heads of schools, in eight out of ten cases, prefer to obtain men from industry and to train them as needed rather than to take men already in the teaching profession. The other two follow the same plan to a limited degree. Four out of twelve heads prefer to appoint alumni of their own schools, and four others to a minor extent only. With the exception of one school (Bliss) where 12 out of 14 teachers are alumni, the proportion is relatively small; 3 out of 30 in one case, 3 out of 34 in a second, 3 out of 31 in a third and 7 out of 33 in a fourth. Few engineering colleges could show so small a degree of in-breeding. One director comments significantly:

> ''The best teachers have been developed from young college graduates coming here after two or three years of good engineering or industrial experience and serving for four or five years as assistant teachers, their all-round development going forward meanwhile.''

Qualifications Most Emphasized.—While most of the directors prefer men of college training, few insist rigidly upon it. Previous teaching experience is stressed by but one man, and then only a par with other qualities. Eleven of the twelve who expressed themselves consider industrial experience *highly essential.* All agree however, in placing the highest weight on personal characteristics, such as moral character, leadership, common sense, ability to maintain morale and interest, and the like.

The estimates of essential qualities which the teachers base on their own experience can best be expressed by brief quotations from their comments:

> ''Knowledge of his subject, sympathetic understanding of the student difficulties, ability to clearly present the subject and its relation to industry.''
>
> ''Practical knowledge and a generous amount of common sense.''
>
> ''A good technical and practical training. Should thoroughly enjoy mechanical work and contact.''
>
> ''Technical education and practical experience.''
>
> ''Ability to inspire and quicken the observation. Enthusiastic and patient. One able to cultivate a love of the work. One whose psychology can make the ideal practical.''
>
> ''Master of his trade and able to impart it to the student.''

"'Practical knowledge, strong personality.''

''Ability, personality.''

''A broad-minded instructor with unlimited practical knowledge and experience.''

''He should know his subject and be a careful, capable, conscientious law-abiding individual of good moral character, tactful and attentive to details.''

''Theory and practical experience is essential.''

''Depends upon what he teaches. A good education for theoretical subjects, coupled with valuable experience for the professional subjects.''

''He should 'be sold' on its possibilities; he should enjoy teaching and seeing others learn, and should thoroughly master his subject.''

''A good personality; common sense; a fair knowledge of his subject and its *relation to other work.*''

''Pleasing personality, ability to present subject clearly, interestingly and with force; ability to handle men.''

''Industrial viewpoint, practical aspect, broad mastery of subject, agreeable personality.''

''Education, appreciation of the difficulties non-students meet in the subject; initiative; control of others.''

''Superior teaching efficiency.''

''Teaching efficiency.''

''Good educational judgment and the ability to demonstrate abstract theory correctly.''

''Must have practical experience. Must be a good leader of students, not a lecturer.''

''Knowledge of industry, and sympathy with aims and circumstances of his individual students.''

''Education with practical experience sufficient to teach fundamentals thoroughly without the use of higher mathematics.''

Turnover of Teachers.—Comprehensive data for estimating the annual turnover are not at hand. The direct testimony is to the effect that resignations and changes among the full-time department heads in the day schools have been rare during the past five years, and that a very moderate number have left the junior ranks. Three times as many teachers leave to enter industry as to take other teaching positions. The total annual turnover in the day schools may be estimated at roughly 5 per cent, as compared with about 10 per cent in engineering colleges. The latter, however, constitute an open market among themselves, where the technical institutes of much more individual character do not. Turnover in evening part-time staffs is naturally much higher.

Salaries.—Three institutions of the most substantial type, all in Eastern cities, reported the salary distributions of their full-time staffs as follows:

SALARIES OF FULL-TIME TEACHERS

Annual Salaries	Institutions and Numbers of Persons		
	A	B	C
To $1900 inclusive	1	0	1
$2000–$2499	2	10	2
$2500–$2999	0	2	4
$3000–$3499	1	8*	2*
$3500–$3999	4*	1	2
$4000–$4499	2	0	3
$4500–$4999	1	3	1
$5000–$5499	0	2	0
$5500–$5999	0	2	0

Note—* indicates median range.

Three other full-time institutions reported their annual salaries without giving data on the distribution in full, as follows: Institution D, $2100, $2210, $2680, $2900, $3000, $3400, $6000; Institution E, $2060, $2520, $3300, $3300; Institution F, $2100, $2400, $2700, $2700, $3420. It may be inferred that the three institutions A, B, and C represent the most favorable side of the picture, with median salaries corresponding to those among the teachers in engineering colleges.

Salaries paid for evening teaching are difficult to coordinate. The range extends from a minimum of $2.00 per hour to a maximum in excess of $1000 a year. When hourly rates are paid, $3.00 is a fairly representative figure.

Supplementary Earnings.—The technical institutes, as a group, seldom place rigid restrictions on the non-teaching activities of their staffs. Typical comments are:

> "We discourage any outside work which will interfere with the efficiency of any member of our staff."
>
> "Teachers are encouraged to obtain higher degrees in the local university or elsewhere."
>
> "No other teaching permitted. Private technical work and services to paying clientele permitted within proper bounds."
>
> "The Institute employs the full time and energy of faculty members during the ten months of the year."
>
> "Restricted by department heads."
>
> "All teachers must secure written consent."

The three institutions designated as A, B and C in the tabulation of salaries on page 155 gave comprehensive data on the non-teaching earnings of their staffs as follows:

SUPPLEMENTARY EARNINGS OF FULL-TIME TEACHERS

Annual Supplemental Earnings	Institution and Number of Persons		
	A	B	C
None	7	2	3
$100–$399	1	6	4
$400–$699	1	3	2
$700–$999	0	2	0
$1000–$1299	0	3	4
$1300 and up	0	2	0
No answer	5	10	0
Maximum	$500	$10,000	$1,000

Two of the evening schools of the most substantial character, both of which use as teachers men who are actively employed in industry during the day, gave the distribution of non-teaching incomes among their staffs as follows:

NON-TEACHING SALARIES, PART-TIME TEACHERS

Institution	Income Ranges and Numbers of Persons							
	Below $2000	$2000–$2499	$2500–$2999	$3000–$3499	$3500–$3999	$4000–$4499	$4500–$4999	$5000 or more
M	3	8	7*	6	4	3	1	0
N	3	5	1	9*	6	6	1	1

Note: Median groups are indicated by *.

Another evening institution of less substantial character reported the non-teaching incomes of its part-time staff as follows: No answer, 8; no income, 1; \$2100, 1; \$2880, 1; \$2900, \$3000, 1; \$4000, 1; \$4200, 1.

It is apparent that part-time evening teaching enlists but few high salaried men. Apparently the desire for supplemental income is the usual inducement which draws men into this work although many evening teachers work with marked devotion and success.

Professional Standing and Activities of Teachers.—There are wide variations from school to school in the professional connections and activities of teachers. In one full-time engineering school 28 out of 33 teachers are members of one or more professional societies. The general average of teachers maintaining such professional connections is much lower, viz., 62.3 per cent of the total reporting. Only about one in seven is a member of the Society for the Promotion of Engineering Education and there is no other organization which even approximates a common bond of interest. The resulting sense of isolation and of lack of common consciousness among their teachers has apparently been an appreciable factor in holding back the development of schools of this character, in marked contrast to the engineering colleges. Other forms of professional activity are fairly uncommon: 28 per cent report that they have published "something," including 6 per cent who have written books and 9.5 per cent who have contributed to periodicals. One-sixth of those reporting have prepared lesson sheets and manuals. A relatively large number, one in five, have made one or more inventions.

D. METHODS AND MATERIALS OF TEACHING

General Observations.—Everywhere one finds the theoretical aspects of subject matter much abridged and training in application much stressed in comparison with college teaching. There is a manifest endeavor to teach underlying physical principles thoroughly, but not profoundly. Cultural subject matter is almost wholly excluded. The fact that limited time means intensive work is constantly impressed on the minds of students. Time schedules are heavy, and rigid standards of regularity in attendance and punctuality in performance are usually insisted upon. Special teaching materials rather than conventional texts are in wide use. With these differences in emphasis, however, the methods of teaching and assignment and the checking of students' progress conform to widely accepted practices and resemble in general those in use in the engineering colleges.

Selection of Materials.—In a few schools the materials of teaching are scrutinized by a committee of the faculty. In practically all close cooperation between departments is secured through frequent conferences, arranged on the initiative of the executive head of the school or division. In one school (Bliss) constant revision of teaching material is in process, while in another (Pratt) the curricula are ''set'' after many conferences and remain unchanged for an agreed-upon period. The intensive character of work makes for close attention to curriculum and schedules, yet there are a few institutions where very little collective study is given to teaching materials and the cooperation of departments is not evident. A few instructors seem to have a very uncertain idea of the responsibility for choosing teaching material. They go on their own judgment as long as nobody objects, but the amount of *laissez-faire* supervision is decidedly less than in college circles. Wherever distinctive or original courses have been developed locally, there is close cooperation among faculty members in administering the curriculum.

Special teaching manuals and the outlines are used in the majority of classes, the authors being for the most part the teachers in charge. One meets frequent comment to the effect that ''no published material suits our situation.'' This condition is accentuated by the individuality of the schools, which greatly restricts the market for published text-books. When one observes the standardizing influences of the text-book in the engineering colleges the greater individuality of the technical institutes is distinctly refreshing and bespeaks a far greater flexibility of aims and methods, whatever its effect on efficiency.

Methods of Teaching.—No striking originality of method and no characteristics or distinctive practices could be found, either by questionnaire or by direct observation. Extended inquiry and inspection would undoubtedly reveal novel or even unique procedure here and there, to a degree equal to that in the colleges. The obvious fact is that most of the teachers are the product of conventional training and do not stray far from the paths in which they were themselves led, except as they are influenced by constant pressure to intensify the work.

The following questions was put to all the administrative heads:

> *In what particulars do your teaching methods differ from those of* (*a*) *liberal arts colleges;* (*b*) *engineering colleges?*

Except for pointing out general dissimilarity, the answers under (*a*) do not particularize. Selected replies to (*b*) may be of interest:

> ''A maximum amount of student participation in well-planned class activities.'' (Cleveland Y. M. C. A.)
>
> ''Theoretical subjects are preceded by practical training.'' (Milwaukee School of Engineering.)
>
> ''More recitations, less laboratory.'' (Newark Technical School.)
>
> ''Founded on engineering teaching, with limited list of subjects, taken many times each week, large percentage of drawing, laboratory, and shop work, and considerable outside study necessary.'' (Ohio Mechanics Institute.)
>
> ''Less dependence on lectures.'' (Pratt.)
>
> ''Entirely different technique of curriculum design (job analysis) and general difference in class administration.'' (Rochester Mechanics Institute.)
>
> ''No laboratory periods. Otherwise conducted the same.'' (Rutgers Extension.)
>
> ''Do not differ appreciably in general. More individual attention is given the student in assisting him to grasp the sub-

> ject.'' (Penn State Extension.)
>
> ''Very similar.'' (Wentworth.)
>
> ''Greater use of project method.'' (Westinghouse.)
>
> ''An intensive training is given in the essentials of each course so that the student can make immediate practical use of it in the industry.'' (Chicago Technical College.)

A second question of related character sought to ascertain

> *In what particulars do the content of subjects differ from that in (a) liberal arts colleges and (b) engineering colleges?*

The answers to part (a) were all general in character, but part (b) elicited more specific information of which the following excerpts are representative:

> ''They are similar but treated in a non-mathematical way.'' (Bliss.)
>
> ''Within the curriculum subjects are arranged to lead more quickly to an employment objective.'' (Cleveland Y. M. C. A.)
>
> ''Practical subject matter given in the first year for theoretical work in the second year, also first year subjects give vocational training of economic value.'' (Milwaukee School of Engineering.)
>
> ''Our curricula are designed to be efficient for their purpose, irrespective of comparison with college practice.'' (Pratt.)
>
> ''Selected in the light of job analysis.'' (Rochester.)
>
> ''Less theory and more practical applications; as both teachers and students are employed during the day, specific personal problems are frequently discussed.'' (Penn State Extension.)
>
> ''Very similar, but intensified.'' (Wentworth.)

In general, this series of replies tends to confirm the impression that technical institutes are dealing with *learners* rather than *students,* that orderly and thoughtful *doing* takes a larger place than book *study,* and that the servicable ends in view lie in the *near* rather than the *distant* future.

Standards and Grading.—The effort to learn what features of the work are given special weight in the grading of students elicited few specific replies. In most instances all the work assigned has its proportional weight, without distinction between class work and practical performance. One director makes the following comment:

> "Personal traits, particularly growth, are considered at graduation."

Few institutions set any specific requirements for graduation beyond a satisfactory record in punctuality, attendance, conduct and performance of work. One insists that the student show "employability"; another school tests this quality by its cooperative plan and insists further on "satisfactory personal trait rating and good disciplinary record"; a third requires that the student "must be morally sound, have paid all his debts to the college and outside parties, as certified to the head of the Welfare Department."

While the technical institutes apparently aim less at homogeneity than the colleges and concede more to the individual differences, the firmly established day schools have a foundation standard of rather rigid character. Men do fail or are delayed in graduation, and some are dropped outright. In no case, however, does the degree of elimination approach that commonly prevailing in the colleges. The reasons, of course, are fairly apparent. Many enter college because it is an accepted thing to do, with no clear purposes and with no real test of aptitude or interest, while entrance to technical institutes is more selective on the part of the students. Furthermore the course is more practical and goals of tangible economic achievement are not so distant.

The available data on the proportion of students who drop out of their courses do not admit of precise evaluation, being based on drop-outs in the year 1927–28 and the first two-thirds of 1928–29, on the one hand, and the enrollments as of September 1928 and February 1930. Where the enrollments may be considered as relatively stable, the indicated percentage of loss per year runs as follows: *Day Schools*—Bliss, 4 per cent; Chicago, 10 per cent; Ohio Mechanics, 18 per cent; Pratt, 9 per cent; Rochester, 23 per cent; and Wentworth, 14 per cent. *Evening Schools*—Newark, 16 per cent; Westinghouse, 25 per cent. While not explicitly stated, it is to be inferred that these are drop-outs during the school year and do not cover the losses of those eligibles who fail to return after vacations.

The reasons assigned by administrative heads for drop-outs are highly variable. At Bliss 20 per cent are attributed to sickness, 73 per cent to scholarship and 7 per cent to finances. Chicago Technical College, by way of contrast, ascribes 6 per cent to illness, 1 per cent to scholarship, 90 per cent to finances and 3 per cent to absences due to work. At Pratt losses are due chiefly to finances and health; at Ohio Mechanics to scholarship and loss of interest. Rochester accounts for approximately 10 per cent each under sickness, finances, transfers and discipline, 32 per cent under scholarship and 37 per cent under loss of interest. Wentworth divides the causes equally between scholarship, sickness and finances. Newark, which has an exceptionally heavy evening schedule, accounts for 20 per cent each under scholarship and sickness, 10 per cent under finances, 5 per cent under absences, and the remaining 20 per cent under "lack of moral stamina." Westinghouse ascribes half its losses to absence and scholarship, one-fifth to illness and 30 per cent to pressure of day employment.

In the 1-year course at Bliss nearly one-fifth of the class failed to graduate on time in 1928; in 2-year courses at Wentworth about one-seventh of the seniors failed in the same year. At Rochester the policy is "to change the course before the senior year of all who cannot graduate." Naturally the day-schools of established character graduate a much higher proportion of their enrollment than can be expected in evening courses which extend over a much longer total period and run parallel to full-time employment. A few examples will in-

GRADUATION RATIOS

Institution	Graduates	Enrollment	Ratio	Ratio × Years
Bliss	316	350	.90	.90
Pratt	180	467	.39	.78
Rochester*	52	305	.17	.52
Wentworth	119	300	.40	.80
Newark	100	1650	.06	.24
Westinghouse	32	327	.10	.39

* 2 courses only.

dicate the general situation. Both the ratio of graduates to enrollment and this ratio multiplied by the years of length of the course are given as of 1927–28.

E. Teaching Loads and Working Schedules

Teaching Loads.—The lack of common units of measurement and comparable conditions makes it impossible to give a simple and definite picture of the situation. In general, the clock hours of teaching or of formal "contact" with student groups are higher than in the colleges and range from 18 to 35 hours per week. When evening classes are held in the same institution the teachers are usually required to do part of their work in both divisions and in a few instances receive additional salary for their evening work. The number of students per class section is very frequently from 35 to 40, while in laboratory, drawing or shop exercises one usually finds from 15 to 25 students per instructor. Typical reports made by teachers are given as examples based on weekly loads; with hours shown separately for day and evening in Fig. 27.

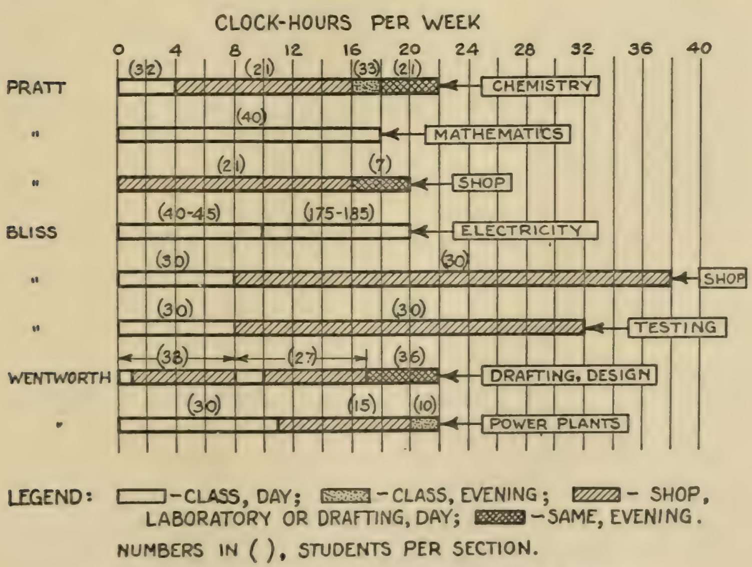


Fig. 27. Typical teaching loads in technical institutes.

The answers of administrative heads to a third question in this series:

> *What special features do you emphasize in your program of teaching?*

were in a similar temper to the above. One director adds, significantly,

> "Students do all the work, teachers merely suggest." (Newark.)

A series of questions put to teachers throw more detailed light on prevailing methods:

> *Are text assignments preceded or followed by explanations and discussions with the class?*

The answers may be summarized thus: *Precede,* 29 per cent; *Follow,* 16 per cent; *Both,* 55 per cent.

> *Approximately what proportion of the students' work in your subject is done in the school under supervision?*

The teachers were asked for general estimates under three heads, with the following replies: *Not more than one-third,* 15 per cent of the teachers; *one-third to two-thirds,* 37 per cent; *more than two-thirds,* 48 per cent. Nearly 80 per cent of the 229 teachers replying estimated that *more than one-half* of the students' work is under supervision. Answers to the question:

> *Approximately what portion of the assignments consists (a) of text material; (b) of exercises?*

may be summarized as follows:

PORTION OF ASSIGNMENTS	PERCENTAGE OF REPLIES BY TEACHERS	
	Text Material	Exercises
Less than one-third	45	29
One-third to two-thirds	32	27
More than two-thirds	23	44

Scheduled Hours of Students' Work.—The schedules of hours of attendance by students are approximately equal to those commonly found in the engineering colleges and greatly in excess of those prevailing in purely academic institutions.

TYPICAL WORK SCHEDULES OF STUDENTS

	Clock Hours per Week	
Day Institutes	Performance	Outside Preparation
Bliss	35	15
Chicago	36	20
New Bedford	32½	10 (at least)
Ohio Mechanics	32½	12–15
Pratt	30	21
Wentworth	30	15
Evening Institutes		
Cleveland Y	9	12
Newark	10–13	4
Rutgers Extension	5	5
Penn State Extension	5	5
Westinghouse	7	9

These schedules bear out the estimates previously given, which indicate that more than half and, on the average, probably two-thirds of the students' total work is done on school premises under teaching supervision. The school year, in most cases, is much the same in length as that of the colleges, viz., from 32 to 38 weeks. Milwaukee, with 48 weeks of operation and the Extension classes of Rutgers and Penn State with 24 weeks, mark the upper and lower limits. These facts and the above schedules emphasize further how far short the extension classes fall of fulfilling the purposes of established institutions. In the half-time cooperative courses, Rochester requires 19 weeks of school attendance per year and Ohio Mechanics Institute 21.

The division of time between class and practical exercises varies with the type of work. In day courses the average division, as in the engineering colleges, is not far from an equal number of clock hours. The proportion of practical work which aims at immediate or early application, however, is much higher in the technical institutes. In the established evening schools the average ratio is roughly two hours of class work to one of practical exercises, while in the extension courses little or no practical work is provided for.

F. CURRICULA

The examples which follow have been selected as representative of the principal types of technical institute curricula. In general, the division of time is given in clock hours, rather than semester-hours or credit-hours, as the latter are of variable significance. A typical junior college course, preparing the student for transfer to the third year of a college of engineering, is shown for comparison with the terminal courses of the technical institutes.

GROUP 1. DAY COURSES IN INDUSTRIAL TECHNOLOGY

NEW BEDFORD TEXTILE SCHOOL

New Bedford, Mass.

3-YEAR COURSE IN GENERAL COTTON MANUFACTURING

First Year	Clock Hours	Second Year	Clock Hours
Pickers and cards	121.9	Roving and spinning frames	187.5
Cards and drawing frames	121.9	Doubling, drafting and testing	103.2
Weaving	243.8	Weaving	140.6
Cloth analysis	112.5	Cloth analysis	131.3
Designing	56.3	Designing	121.9
Hand loom	56.3	Cotton sampling	37.5
Yarn calculations	28.1	Dyeing	112.5
Warp preparation	65.6	Textile chemistry	121.9
Principles of mechanics	18.8	Testing	18.8
Mechanical drawing	150.0	Machine drawing	75.0
Chemistry	121.9	Machine shop practice	131.3
Textile chemistry and dyeing	121.9	Steam engineering	37.5
	1,219.0		1,219.0
Third Year			
Combers and mules	187.5	Data	
Carding and spinning	187.5	Total clock hours—three years	3,657.0
Weaving	243.8	Weeks per school year	37.5
Designing	112.5	Clock hours per week	32.5
Color	75.0	"There is no stated length of time for our lecture periods and our laboratory periods because the lectures often overlap the allotted time, or fall short; however, we usually figure two-thirds of the time for laboratory work and one-third for lectures."	
Cloth analysis	121.9		
Knitting	56.3		
Converting	56.3		
Cost finding	28.1		
Mill engineering	56.3		
Machine shop practice	56.3		
Elementary electricity	37.5		
	1,219.0		

It is distinctly noted that this course does not aim principally at craftsmanship. Even where actual operating is a part of the exercises special attention is given to a study of the machines, including their design, construction, and uses. From the catalog—"These courses are intended to qualify students to hold positions of responsibility in textile manufacturing and allied establishments." Also, "Those making application for admission to this course must be High School Graduates, present proof of an equivalent education or pass entrance examinations."

Ohio Mechanics Institute

Cincinnati, Ohio

2-Year Cooperative Power Laundry Course

Theoretical chemistry
Show work
Laundry technology
Business English
Cost accounting and business practice
Steam engineering
Elementary electricity
Textile fabrics

Applied chemistry
Heating and ventilation
Laundry technology
English conferences
Laundry accounting
Advertising and salesmanship
Strength of materials
Elementary electricity
Economics

Data

School Weeks per Year	20
Work Weeks per Year	20

"Applicants for this course should be at least eighteen years of age. Three or more years of high school preparation are necessary, and the completion of a high school course is desirable. A certain amount of practical experience in some business line or in laundry work is also desirable, but not absolutely necessary.

"The purpose of the Power Laundry Cooperative Course is to train young men to become foremen, superintendents, and assistant managers of power laundries, through the technical and vocational classes taught in the Ohio Mechanics Institute and the practical laundry work done in commercial laundries in Cincinnati and vicinity. The Power Laundry Cooperative Course began in September, 1920, and the first class was graduated in June, 1922. The graduates have been immediately absorbed by the laundry industry, showing the demand for men with this type of training.

"Under the cooperative plan, the student studies four weeks at the Institute and then works four weeks in the laundry. A member of the faculty acts as supervisor or coordinator, and, after obtaining jobs for the men, keeps in close touch with the practical, or cooperative, work of each student in the laundry."

AMERICAN INSTITUTE OF LAUNDERING

Joliet, Ill.

1-YEAR COURSE IN LAUNDERING

	Clock Hours			Clock Hours		
	Class	Lab.	Total	Class	Lab.	Total
I. Power plant engineering—1st eight weeks				128	120	248
Mathematics	24	0	24			
Drawing	0	48	48			
Steam power	40	24	64			
Electricity	40	24	64			
General laundry engineering	16	24	40			
Engineering seminar	8	0	8			
II. Plant production—2d eight weeks				48	216	264
Production methods	40	96	136			
Mechanical drawing (plant layout)	0	120	120			
Production seminar	8	0	8			
III. Textiles and washroom practice—3d eight weeks				120	160	280
Applied chemistry	40	50	90			
Washroom practice	40	60	100			
Textiles	40	50	90			

	Clock Hours			Clock Hours		
	Class	Lab.	Total	Class	Lab.	Total
IV. Accounting and office administration—4th eight weeks				180	100	280
Cost accounting	50	20	70			
Laundry accounting	65	80	145			
Business law	16	0	16			
Office management	24	0	24			
Commercial arithmetic	25	0	25			
V. Sales, service and advertising—5th eight weeks				218	62	280
Elementary advertising	34	0	34			
Market analysis	14	0	14	694	658	1,352
Advertising media	20	0	20			
Advertising campaigns	20	0	20			
Layouts and copywriting	0	34	34			
Selling fundamentals	34	0	34			
Selling process	20	0	20			
Sales organization	34	0	34			
Service	14	0	14			
Applied sales and service	28	28	56			

Data

Total Clock Hours—One year	1,352
Weeks per School Year	40
Clock Hours per Week	33.8

Graduation from a standard preparatory course or the equivalent of fifteen units of high school credit is the minimum ideal requirement for admission. This, alone, will not assure acceptance nor will the lack of it automatically mean the rejection of an applicant. The quality of the secondary work, the character, personality, intelligence and health of the student, as indicated by his accomplishments and attitude in school and out, are carefully considered. Students can enter at the beginning of any eight-week period. The course is organized definitely on the unit basis. One of its objectives is the training of young men as potential managers in the art, science, and practice of laundering.

WENTWORTH INSTITUTE

Boston, Mass.

2-YEAR COURSE IN POWER PLANT PRACTICE

First Year	Clock Hours			Second Year	Clock Hours		
	Class	Lab.	Total		Class	Lab.	Total
Applied science	45	90	135	Steam	120	225	345
Electricity	60	120	180	Electricity	90	135	225
Steam	45	45	90	Mechanics	45	30	75
Mechanical drawing	0	180	180	Mathematics	30	0	30
General chemistry	30	60	90	Mechanical drawing	0	165	165
Mathematics	120	0	120	English	30	0	30
English	30	0	30	Shop practice	0	180	180
Shop practice	30	195	225				
	360	690	1,050		315	735	1,050

The above course is intended to give thorough instruction in theory and practice so that the students may qualify for positions in power plants and transformer stations, and may be able to undertake the installation of equipment.

2-YEAR COURSE IN FOUNDRY MANAGEMENT AND OPERATION

First Year	Clock Hours			Second Year	Clock Hours		
	Class	Lab.	Total		Class	Lab.	Total
Applied science	45	90	135	Chemistry	60	180	240
Electricity	60	120	180	Electricity	45	45	90
Steam	45	45	90	Mathematics	60	0	60
Mechanical drawing	0	180	180	Drawing	0	90	90
General chemistry	30	60	90	Materials	30	30	60
Mathematics	120	0	120	English	30	0	30
English	30	0	30	Shop practice	60	420	480
Shop practice	30	195	225				
	360	690	1,050		285	765	1,050

This course is intended to prepare trained specialists in the foundry industry, who can effectively and economically apply the many new methods which have been introduced in recent years into foundries to produce castings of uniform quality and finish at a minimum of cost.

Data

Total Clock Hours—Two Years	2,100
Weeks per School Year	35
Clock Hours per Week	30

"Applicants for admission to both of the above courses should be eighteen years of age or over. They should be high school graduates, or young men with industrial experience and sufficient training to pass the entrance examination. A certificate of graduation from any high school, in a course which includes mathematics, and drawing or science, with a recommendation from the high school principal as to attendance, character, and mechanical ability, is accepted in lieu of the entrance examination."

Chicago Technical College

Chicago, Ill.

2–Year Course in Building Construction

First Year	Clock Hours		
	Class	Lab.	Total
Builder's arithmetic	18	0	18
Algebra	180	0	180
Geometry	180	0	180
Physics	90	0	90
Plan reading	36	252	288
Engineering drawing	0	108	108
Construction and working drawing	0	324	324
Building construction	36	0	36
Roof framing and use of steel square	18	0	18
Business Correspondence	54	0	54
Inspection trips			
	612	684	1,296

Second Year	Clock Hours		
	Class	Lab.	Total
Trigonometry	54	0	54
Physics	54	0	54
Mechanics and strength of materials	90	0	90
Advanced plan reading	36	108	144
Contracting and estimating	72	108	180
Contracts and specifications	18	0	18
Materials of construction	36	0	36
Architectural drawing	0	216	216
Building construction, designing, detailing	18	216	234
Builder's level and laying-out foundation	18	54	72
Heating, ventilating, plumbing, and sanitation	36	0	36
Technical and report writing	36	0	36
Practical economics	36	0	36
Business law	36	0	36
Business administration	36	0	36
Building ordinances	18	0	18
Inspection trips			
	594	702	1,296

GROUP 2. DAY COURSES IN ENGINEERING

Chicago Technical College

Chicago, Ill.

2-Year Course in Civil and Structural Engineering

First Year	Clock Hours		
	Class	Lab.	Total
Algebra	180	0	180
Geometry	180	0	180
Trigonometry	54	0	54
Engineering drawing	0	108	108
Physics	90	0	90
Plan reading and building construction	36	36	72
Plane surveying	36	144	180
Business English	54	0	54
Drawing structural shapes and sketching	0	270	270
Steel building construction and erection drawing	0	162	162
Slide rule	12	0	12
Inspection trips			
	642	720	1,362

Second Year	Clock Hours		
	Class	Lab.	Total
Mechanics and strength of materials	90	0	90
Graphic statics and stresses	72	0	72
Topographic surveying and mapping	72	108	180
Physics	54	0	54
Building estimating and cost analysis	36	0	36
Drafting in steel construction	0	216	216
Reinforced concrete and masonry design	90	0	90
Hydraulics and water supply	54	0	54
Highway engineering	54	54	108
Bridge stresses and design	36	0	36
Municipal engineering	54	0	54
Structural detailing and design	36	270	306
	648	648	1,296

Data

	Building Construction	Civil and Structural
Total Clock Hours—Two Years	2,592	2,658
Weeks per School Year	36	36
Clock Hours per Week	36	36.9

"Applicants for admission (to the two courses of the Chicago Technical College) should be at least 16 years of age. Students may be admitted on certificate, by examination, on credits from another college, or by a combination of these. Day students who have not completed high school courses will have the necessary high school subjects included in their courses at the College; such students are required to submit credits for work they have completed in high school.

"The aim of these courses is to give students a maximum of practical training in a minimum of time, and to prepare them for specific places in the industrial world. The purpose of the College is to place technical training of college standard within the reach of men who have not either the time, the money or the preliminary education to attend a university."

PRATT INSTITUTE

Brooklyn, N. Y.

2–YEAR COURSE IN INDUSTRIAL MECHANICAL ENGINEERING

First Year	Clock Hours		
	Class	Lab.	Total
Physical elements of engineering	156	240	396
Chemistry	48	72	120
Mathematics	180	0	180
English	24	0	24
Mechanical drawing and descriptive geometry	48	132	180
Shop work	0	180	180
Physical training	24	0	24
	480	624	1,104

Second Year	Clock Hours		
	Class	Lab.	Total
Mechanical technology	168	432	600
Electrical technology	84	48	132
Mathematics	108	0	108
Machine shop	0	216	216
Industrial administration	36	0	36
Physical training	12	0	12
	408	696	1,104

Data

Total Clock Hours—Two Years	2,208
Weeks per School Year	36
Clock Hours per Week	30.7

This is a course of technical preparation for positions concerned with supervision, engineering, production, sales and management in manufacturing industries, power plants, and transportation systems.

2-YEAR COURSE IN INDUSTRIAL ELECTRICAL ENGINEERING

First Year	Clock Hours		
	Class	Lab.	Total
Physical elements of engineering	156	240	396
Chemistry	48	72	120
Mathematics	180	0	180
English	24	0	24
Mechanical drawing and descriptive geometry	48	120	168
Shop work	0	192	192
Physical training	24	0	24
	480	624	1,104

Second Year	Clock Hours		
	Class	Lab.	Total
Electrical technology	144	504	648
Mechanical technology	108	48	156
Mathematics	108	0	108
Machine shop	0	144	144
Industrial administration	36	0	36
Physical training	12	0	12
	408	696	1,104

Data

Total Clock Hours—Two Years	2,208
Weeks per School Year	36
Clock Hours per Week	30.7

"This course is designed especially to train men for employment in the electrical manufacturing industries, in power, lighting, railway and telephone service, and in many other industries and occupations where technical knowledge of electricity and electrical apparatus is involved."

"For the guidance of prospective candidates for admission specific mention is made of the following typical instances:

1. "High or preparatory school graduates without industrial experience receive favorable consideration unless they

appear to be lacking in maturity or definiteness of purpose, in which case they may be advised to seek industrial employment in further preparation for this School.

2. ''Industrially experienced candidates, who are above high school age, may qualify for admission irrespective of want of previous schooling, provided the School is satisfied of their ability to profit from the course of instruction.

3. ''Applicants whose preparation chiefly comprises schooling will be expected to complete a full high school course, or its equivalent.

4. ''Applicants who are less than 18 years of age are seldom able to meet the requirements for admission and will be considered only in exceptional cases.

''More importance is attached to the definiteness of purpose, maturity, and general fitness of the candidate, than to his academic record or ability to pass the set entrance examinations.''

Bliss Electrical School

Washington, D. C.

1-Year Course in Electrical Engineering

First Year	Clock Hours	Data
Theoretical electricity........	480	Total clock hours—One year... 1,131 Weeks per school year........ 32 Clock hours per week......... 35.3 "To be admitted as a student the applicant must have a common school education including a good working knowledge of arithmetic. Electrical or mechanical experience is not necessary. The acceptance of any applicant depends upon the information contained in his application or contained in other sources."
Slide rule..................	10	
Mathematics...............	120	
Prime movers..............	40	
Mechanical drawing.........	160	
Electrical tests..............	107	
Machine shop..............	107	
Wiring and meter testing.....	107	
	1,131	

Note.—A study of the students at Bliss Electrical School showed that between 70 per cent. and 75 per cent. were high school graduates.

"The Bliss Electrical School is neither a trade school nor a college. It is a special technical school. *It is not a preparatory school—it is a finishing school.* Its graduates are qualified to enter some branch of the engineering profession at once."

GROUP 3. EVENING COURSES

NEWARK TECHNICAL SCHOOL

Newark, N. J.

4-YEAR EVENING ELECTRICAL COURSE

First Year	Clock Hours	Second Year	Clock Hours
Trigonometry	54	Mathematics analysis	108
Elements of electricity and magnetism	108	Analytics Calculus	
Mechanical drawing	54		
English	54	Direct currents and D.C. machinery	108
		Applied mechanics	54
	270		270

Third Year	Clock Hours	Fourth Year	Clock Hours
Calculus	54	Electrical engineering	108
Alternating currents and A.C. machinery	108	Class room Laboratory	
Class room Laboratory		Economics and business administration	54
Mechanics of materials	54	Applied mechanics	54
Accounting	54	Machine design	54
	270		270

Data

Total Clock Hours—Four Years	1,080
Weeks per Year	27
Hours per Week	10
Evenings per Week	5
Hours per Evening	2

DREXEL INSTITUTE

Philadelphia, Pa.

4-YEAR EVENING ELECTRICAL COURSE

First Year	Clock Hours	Third Year	Clock Hours
Electricity and magnetism	96	Alternating currents	144
Principles of electrical engineering	48	Alternating current machinery	72
Mathematical analysis	72		216
	216		

Second Year	Clock Hours	Fourth Year	Clock Hours
Principles of electrical engineering	48	Alternating current machinery	144
Direct current machinery	48	Electrical power transmission or power plants	72
Applied mathematics	120		216
	216		

Data

Diploma in Electrical Engineering—Total Hours in Class	864
Number of Evenings per Week	3
Number of Hours per Evening	2

EXTENSION DIVISION, PENNSYLVANIA STATE COLLEGE

Erie, Pa.

3-YEAR EVENING MECHANICAL COURSE

First Year	Clock Hours		
	Class	Lab.	Total
College algebra and trigonometry	30	0	30
Analytic geometry and calculus	30	0	30
Mechanical drawing *	0	60	60
	60	60	120

* Actual drawing is done at home—Instructor's corrections only during class hours.

Second Year	Clock Hours		
	Class	Lab.	Total
Mechanics	60	0	60
Heat and thermodynamics	30	0	30
Steam power plant equipment and auxiliaries	30	0	30
	120	0	120

Third Year	Clock Hours		
	Class	Lab.	Total
Strength of materials	30	0	30
Internal combustion engines	30	0	30
Kinematics	0	30	30
Machine design	0	30	30
	60	60	120

Data *

Total Clock Hours, Three Years	360
Weeks per School Year	24
Clock Hours per Week	5

"A knowledge of Arithmetic is the only entrance requirement for any of the three year engineering extension courses except at the Erie Branch School."

It is interesting to compare the hours per week in this program with those shown later for the evening Electrical Courses of the Newark Technical School.

---

* The work in this course is of the technical institute type, yet the total hours in school for the three years do not equal one school-year day course. This is true even when it is considered that the drawing is done at home. In fact, it would require between two and three times the above class hours to equal a normal day school program. At the same time it must not be lost sight that the students are frequently more mature and more deeply in earnest than are the students in the day schools. Few of the extension divisions of the State Colleges or Universities offer a sufficiently extended program to equal the school hours of a year or day school. The extension experience is that by the time the advanced years of a course are reached the original enrollments in the course have scattered and the instruction becomes too expensive per remaining student.

GROUP 4. MISCELLANEOUS

DIVISION OF UNIVERSITY EXTENSION, STATE OF MASSACHUSETTS

Boston, Mass.

3-YEAR COURSE IN ELECTRICAL ENGINEERING

(Class or Correspondence)

First Year	Assignments	Equivalent Clock Hours in School
Practical applied mathematics	12	27
Mechanical drawing *	20	90
Advanced shop mathematics	20	45
Practical mechanics	20	45
		207
Second Year		
Trigonometry *	20	45
Practical and industrial electricity	36	81
Machine design *	20	90
Essentials of alternate currents *	20	45
Practical steam engineering	20	45
		306
Third Year		
Dynamic electric machinery *	20	45
Theory of alternating currents *	20	45
Electric railways *	20	45
Electric transmission *	20	45
Power plant economics *	20	45
		225
		738

"No entrance examinations are given, but each application is passed upon individually. No one is admitted to a course until the Division is satisfied that he is sufficiently prepared to carry the work of the course.

"For the benefit of students who desire to follow a systematic line of study, a course in electrical engineering is arranged here to cover roughly the equivalent of the subject matter of the strictly engineering course at a technical college. A diploma or certificate will be granted for the satisfactory completion of 240 assignments of college grade courses as outlined. In the arrangement given, the courses are spread over a period of three years to accommodate the restricted time that the average adult student, busy with his daily work, can devote to spare-time study."

---

* Post secondary in grade.

FLINT JUNIOR COLLEGE

Flint, Mich.

2-YEAR CURRICULUM IN ENGINEERING

(For admission to third year at Michigan State College)

First Year	Clock Hours		
	Class	Lab.	Total
General chemistry	72	108	180
Mathematics	144	0	144
English	108	0	108
Mechanical and machine drawing	0	108	108
Descriptive geometry	0	108	108
Qualitative analysis	36	144	180
Physical education	0	72	72
	360	540	900

Second Year	Clock Hours		
	Class	Lab.	Total
Physics	144	216	360
Mathematics	180	0	180
Speech	54	0	54
Mechanics	72	0	72
Sketching and drawing	0	72	72
Surveying	36	72	108
	486	360	846

Data

Total Clock Hours—Two Years	1,746
Weeks per School Year	36
Clock Hours per Week	25–23.5

"Applicant may be admitted to the freshman class either by certificate or by examination. The requirements of admission by certificate are as follows:

1. Graduation from an approved high school.
2. Recommendation by the high school principal.
3. Presentation of fifteen satisfactory units of high school credit completed with satisfactory scholastic standing.

"This course provides the first two years of work leading to the degree of Bachelor of Science in Engineering, which may be procured upon the satisfactory completion of two additional years of work in a college of engineering."

G. Cooperative Half-time Plans

Nature and Origin.—The essential feature of the cooperative plan is the alternation of periods of formal instruction in the school, with periods of assigned and supervised industrial experience. Each class is divided into two sections of equal numbers which alternate in their scholastic and industrial schedules, so that neither phase of activity is interrupted so far as school or industry are concerned. The success of the plan depends upon the administrative control of assignments, both scholastic and industrial, by the school authorities and upon their ability to weave the two types of activity together into a unified pattern. The plan had its origin at the University of Cincinnati in 1906, and is to be credited to the initiative of Dr. Herman Schneider, then Dean and now President of that institution. Dean Schneider had earned a large portion of his college expenses by working out of hours in an engineer's office and was so impressed by the values which this experience added to his education that when in later life he himself became an educator he sought to incorporate them into the student's regular program. A somewhat similar arrangement known as the "sandwich plan" * has long been in vogue in Scotland, and more recently in England. The essential difference lies in the fact that the "sandwich" student is first of all an enrolled apprentice in a particular industrial concern under an agreement which permits him to attend a designated technical institution for half the year. Alternating work and study schedules are also the rule in a number of German mining schools.†

---

* See page 221.

Present Use in Technical Institutes.—The cooperative plan has had a very limited trial by the technical institutes. Ohio Mechanics Institute maintains a cooperative power laundry course, which was established at the suggestion of the laundry managers' association. Rochester Mechanics Institute conducts all its day industrial courses under this plan, but has introduced it so recently that a mature experience has not yet been had. The General Motors Institute of Technology, a purely corporation school serving in common the principal units of General Motors, uses the plan in all its courses. While none of its courses lead to degrees, the instruction offered is almost purely of the college type, rather than the more intensive and practical type which characterizes the technical institutes. Furthermore, both the educational and industrial phases are equally under the same control and is of a strictly industrial character. This condition is too anomalous to have the force of an example to the technical institutes in general.

Experience of the Engineering Colleges.—For an appraisal of the plan in the light of broad and fairly mature experience one must turn to the engineering colleges, where it first developed and has had its widest application. It should be emphasized that Dean Schneider's primary aim in instituting the plan was to augment and enrich the educational process. He was seeking to give the student a natural test of aptitude and a realistic orientation to industry; he aimed to test his moral stamina and his fixity of purpose, to enlarge his contacts with an understanding of men of every rank, to subject him to the discipline of regular work including a period of manual labor and to teach him the lessons of economic responsibility. Furthermore he was seeking to reinforce the teaching of the school with collateral experience, to provide a warp of solid actualities on which teacher and student could weave a richer and more authentic pattern of learning by teaching and study. It was soon apparent that certain economies could be realized; that industrial experience offered a substitute for much of the shop-work and some of the drawing ordinarily taught in the college; that a two-shift, all-year plan of operation tended to reduce the overhead cost per student; that the earnings of students in their industrial periods increased their capacity to pay tuition fees as well as easing the burden of their support; and that a somewhat reduced course of study, spread over five tuition years could produce more revenues from a given enrollment than a normal course in four. Here was a closer approach to budget-balancing, both for the college and the student, a wholly desirable thing in itself, but essentially secondary to the real aims in view.

---

† See page 264.

Financial Aspects.—It is to be feared that where one insitution adopted the plan on its educational merits, four were influenced more largely by its financial attractions. One may note that the plan is in use in a group of colleges of the most substantial character, and on the other hand that it has been exploited in order to set up a group of distinctly flimsy institutions, without capital resources and effective plants, with the most meagre scientific and technical equipment, living from hand to mouth on tuition fees which, seemingly moderate in amount, are high in relation to the costs and values involved.

Does It Reduce Plant and Teaching Burdens?—One may read in the announcements of schools of this type ''The industries of . . . are our laboratories.'' Actually this slogan is almost pure window dressing. It has been amply shown that industrial experience, even when closely articulated with college instruction, does not in any way displace the scientific and technical instruction which the school is created to give. A fuller experience is showing that cooperative work in industry may reduce the practical training ordinarily given in college to a very limited degree. The General Motors Institute of Technology, with the fullest possible control over industrial experience, has included shop instruction in its school programs to an unusually high degree. If incidental experience is desired, industrial work alone may serve; but if serious and intensive technical training in the technology of industrial processes, with critical regard to their possibilities and limitations, is the end in view, a shop laboratory under college control is fairly indispensable.

It is even more certain that industrial practice does not diminish in any appreciable degree the need for laboratory instruction in the fundamental and applied sciences. The Massachusetts Institute of Technology maintains cooperative programs with the General Electric Company, certain companies of the Bell Telephone system, and other industrial concerns. These programs are of a ''closely coupled'' type, with each period of industrial experience prearranged in quite as definite a curriculum as the scholastic work. Furthermore, they constitute an educational partnership between the college and industries which are richly provided with laboratory personnel and equipment and use a scientific technique of the highest order. Yet these connections have not led the Institute to abridge in any appreciable degree its own provision for scientific and technical instruction.

In view of a widespread impression that welfare organizations and private interests can establish and maintain successful technical schools, even institutions of university pretensions, under the cooperative plan without capital resources or effective equipment of their own, the Staff feel it their duty to point out explicitly that these assumptions are wholly incompatible with sound experience and standards.

Coordination of Scholastic and Industrial Phases.—The educational values of the cooperative plan are in large measure dependent upon the ability of the school to arrange for each student an orderly and progressive experience program. The ''close-coupled'' programs of the Massachusetts Institute do this in a thorough-going way. The more ''loosely coupled'' programs of the University of Cincinnati are worked out by special coordinators individually as the flow of work will permit. In the former case the student spends all his industrial periods with one concern or with a group of closely affiliated companies working under a common plan. In the latter case, the student works at assignments in several firms unrelated to each other. In an institution having so wide a range of well-stabilized cooperative connections as the University of Cincinnati, the individual programs can be given an orderly and progressive character and yet preserve almost complete adaptability to the needs of individuals and cooperating firms. The less firmly established cooperative schools, with a narrower and more casual group of connections, can offer little more than intermittent education and employment.

Possibilities in Technical Institutes.—Cooperative plans, whether American, British or German, provide the possibility of an effective linking up of technical school with its surrounding industrial community. Technical institutes operating on a civic or community basis ought to find some adaptation of these plans most advantageous. While not positively demonstrated, it seems fairly well indicated that a cooperative course, unless specially organized for that purpose, is less suitable than a continuous program for the training of highly scientific researchers and analysts. On the other hand, there are fairly definite indications that it provides superior training and orientation for supervisory positions.

Something intermediate between the British sandwich plan for indentured apprentices and the cooperative plan for college students seems most suitable for the technical institutes of community type. Working out of details must rest with experience, but a reasonable order of procedure would seem to be:

1. The technical institute establishes contact with groups of employers and concerns and agrees with them on a plan of cooperation.

2. The types of employment suitable for students and the progress routes to higher levels are studied by the aid of job analyses and case records.

3. Specifications are drawn from these analyses and embodied in a plan of instruction to be followed by the Institute and a plan of employment by the industries.

4. A prospective student first establishes his eligibility for admission to the institute, then obtains employment under the above plan with one of the cooperating concerns, the institute acting in an advisory capacity.

5. The institute furnishes records of scholastic performance to employers and obtains from them periodical records of the student's performance and ratings on his personal traits and adaptabilities.

6. Where need arises for a change of employment by a student, the institute advises and cooperates, but does not formally make the placement.

H. FEES AND COSTS

Fees.—Among so scattered and diverse a group of schools little uniformity of fees, costs and standards of value is to be expected. The well endowed institutions are strikingly moderate in their charges, while the proprietary institutions must cover not only their operating costs but their overhead as well and earn a living profit. From the student's view point, the best is likely to be the cheapest, although the cheapest is not always the best.

The following table gives the reported total of fees per year

ANNUAL FEES AND COSTS TO STUDENTS

Day Schools	Fees	Costs
Bliss	$850*	$1000*
Chicago	$294	$ 320
Milwaukee	$395	
New Bedford	$ 5†	
New Bedford	$155‡	
New Bedford	$305§	
Ohio Mechanics	$105‖	
Ohio Mechanics	$305¶	
Pratt	$159	$ 220
Rochester	$150	$ 150
Wentworth	$103	$ 130

* Includes board.

† Residents of Massachusetts.

‡ Non-resident Americans.

§ Foreign students.

‖ Courses in engineering.

¶ Power laundry course.

Evening Schools	Fees	Costs
Cleveland Y. M. C. A.	$131	$131
Lowell Institute	$ 5	
Newark	$ 60*	
Rutgers Extension	$ 45	
Penn State Extension	$ 36	
Westinghouse	$ 2	

* Plus laboratory fees.

and the estimated total cost to the student, exclusive of his purely personal expenses. In one case, however (Bliss), an inclusive charge is made to cover both fees and board.

Operating Costs.—Five day institutes made reports of their operating costs, none of which include interest and amortization of plant investment. The annual costs per student, as reported, are respectively $275, $300, $450, $423, and $400. These figures are of the same magnitude as the costs in publicly supported engineering colleges.† Five evening institutes made similar reports of operating costs, as follows: $46.80, $80, $60, $44, $58.

Allowing for differences in location, as well as in standards among the institutions reporting, it may be inferred that highly effective instruction in the field studied, if provided in institutions of economical size and organization may be expected to cost from $400 to $450 per year per student in full-time day schools, and from $60 to $80 per year per student in evening schools of comparable quality, with overhead charges in addition. While the data at hand do not afford any direct comparison between cooperative and full-time institutions, it should be pointed out that the cooperative plan reduces the direct cost of instruction little, if at all. If sound educational standards are maintained, the savings which accrue are largely in the realm of over-head and these are realized only when the school operates on an all-year schedule.

Outlook for Self-Financing Institutions.—While it is true that proprietary institutions have been able to survive in this area, and in at least one instance (Bliss) to achieve a distinctive educational and financial success through prudent management and personal devotion, the likelihood of other institutions doing so in the future seems to be diminishing. The technical institute will always be pressed by the engineering college on the one hand and the vocational school on the other. The junior college now adds a new hazard. As technical institutes of endowed and public types multiply, the field open to private enterprise will diminish rapidly. There is a fine tradition of welfare motives in technical education, especially in Great Britain, but a more mature experience than our own has brought practically all the institutions which originated under personal or corporate welfare auspices under public control and support. Private interests and religious associations, deriving the means of support wholly from fees and current gifts, may be able to fill gaps in the situation temporarily but can not be counted upon to provide a permanent basis of activity.

---

† See Report of Investigation of Engineering Education, S. P. E. E., Vol. I, pp. 341–349.

I. INFLUENCES OF EMPLOYERS AND ALUMNI

Placement Activities.—The information gathered directly from the schools adds but little to that supplied by employers and alumni, as set forth in Chapters IV and V. Practically all the established day schools make definite efforts to place their graduates. One of the full-time schools (Pratt) selects its students for "employability" and includes placement as a service coordinate with instruction. Rochester meets the placement problem by its cooperative program. In other instances the practices are less formal, though usually fairly effective. Once relations are established with an employer and the product becomes known, the market tends to become continuous, though fluctuating somewhat with economic conditions. Alumni are of great assistance directly in effecting placements; one director (Bliss) works principally through these contacts to keep all his men suitably placed. Evening schools find little need for organized placement service.

Influence of Employers.—Only one instance was reported where employing industries took the initiative in proposing the establishment of a particular course, that in Power Laundry Operation at the Ohio Mechanics Institute. Employers, as a rule, are still too little acquainted with schools and courses in this field to initiate active demands. One director comments: ''Such demands need to be cultivated''; another ''No demand; plain need''; a third, ''Meet specific needs of the community''; and a fourth, ''Think they would be welcomed.''

Example of Organized Local Cooperation.—The Rochester Mechanics Institute requested the Industrial Management Council of the Rochester Chamber of Commerce to appoint a committee to survey the needs of the local industries, to collect job analyses and specifications and to draft from these data specifications for curricula and for cooperative practical training in industry. As an example of the work accomplished, the following sample specification is of interest:*

SCHOOL OF INDUSTRIAL ARTS

Specifications for Mechanics Institute
Graduates of Industrial Day Courses—Mechanical

1. *Mechanical Cooperative Course.*

A. Description of Job.

The Mechanical Cooperative Course can best serve industry by training men to be supervisors. These jobs require a better background or trade theory and related science than that ordinarily possessed by shop trained men. Graduates of this course will fit into industry as potential maintenance men, all-round machinists, tool makers, investigators, tool designers, supervisors or foremen of maintenance or production processes where mechanical equipment or operations are involved; or as salesmen of mechanical equipment.

B. Job Knowledge.

A thorough knowledge of metal working, machine and hand tools, including a general knowledge of mechanics, and mechanical devices and the principles of the ''Art of Cutting Metals''; the requirements for the production and control of the manufacture of interchangeable parts; a thorough knowledge of the trade, such as ''American Machinist's Handbook'' and ''Machinery Handbook''; ability to make calculations and understandingly use tables, formulae and other reference material; ability to read blueprints and make free hand sketches and rough drawings.

---

* From paper by V. M. Palmer, ''Industry Specifies its School Training Needs,'' A. S. M. E., Rochester, N. Y., May 13, 1929.

C. Job Skill.

Sufficient shop training in the Institute to acquire general principles of machine tool operation. Hand skills are to be acquired in industry, rather than in the Institute.

D. Personal Qualifications (Same for all Industrial Art Courses). Bent and liking for the work. Physique. Judgment. Initiative. Understanding of men. Character.

Mechanics Institute should graduate clean living, honest minded, intelligent, straight spoken, dependable men and women, fair to themselves, their employers and fellow employers, and ready for any task, duty or service, arising in connection with their employment.

These specifications were made the basis for ''Detailed Recommendations'' as to preferred training methods and course content. Such a detailed recommendation follows:

1. *Mechanical Course.*

Kind of Course: Part time cooperative.

Length of Course: 2 years, 12 months basis.

Entrance Requirements: At least 17 years old, completed 10th grade or equivalent, including algebra, geometry and physics.

Method: The training of mechanical supervisors should be direct and intensive. The theory these students should get at the Institute is not basic theory (abstract mathematics and science) which they would apply later, but theory directly applicable to the training they get on the job in industry and taught from such handbooks of the trade as ''Machinery's Handbook'' and ''The Machinist's Handbook.''

Subject Matter.

Shop Work: Sufficient shop work at the Institute to give the student a working knowledge of the principles of machine shop tools, processes and materials, but not sufficient practice to develop manipulative skill. Industry can give this.

Drawing: Blueprint reading and shop sketching—pencil course only, sufficient to train the student to make and dimension a pencil sketch, free hand or with scale. Inking in or regular drawing room technique is not necessary for the shop man.

Mechanical drawing should be given as a separate course for draftsman, not as a part of the mechanical course now given.

Related Mathematics and Science: Enough related mathematics and science, with handbooks as tests for both theory and practice, to train the students to use and understand handbooks of the trade, such as "Machinist's Handbook." Give no separate courses in mathematics, science or abstract theory.

Trade Theory: There should be, as a part of the instruction given at the Institute, constant reference to and study of handbook sections applying to work being done in shop, so that by the end of the course the students will be familiar with the handbooks and be able to use them.

Liberal Subjects: The present problem course in industrial history, economics, psychology, and shop management, with the added feature of corrective English, both oral and written, should be continued.

Options: Provision should be made for options during the last eight months of the course, so that the student may concentrate on work in his chosen field.

Attitude of Employers on the Degree Issue.—Three of thirteen directors reporting indicate that employers exert some influence in favor of the substitution of four-year degree courses for their more intensive curricula. The pressure apparently, is not strong nor the attitude common. In fact in every case where employers have been induced to study the situation in detail, the attitude has been quite the reverse.

Influence of Alumni.—In eleven of thirteen institutes which supplied information the alumni are organized and in three cases branches exist for separate courses. The part taken by these alumni bodies in the management of the institutes varies considerably. Social reunions and efforts to interest prospective students are the activities most frequently mentioned. One group has established a loan fund for needy students and two groups maintain scholarships. In only one case, Rochester, do the alumni participate officially in the management of the institute, in this case by nominating two members of the Board of Directors.

The reactions of graduates to their education have already been discussed at length. The heads of the schools are in intimate touch with alumni attitudes and interests and have some further light to add to the subject. To the question:

> *Do graduates bring influence to bear to have the courses changed to a degree basis?*

the answers of the heads of the schools were as follows: Bliss, *no*; Chicago, *yes*; Cleveland Y., *no*; Milwaukee, *yes*; Newark, *yes*; New Bedford, *no*; Ohio Mechanics, *no*; Pratt, *some, but not on the whole*; Rochester, *not openly*; Rutgers Extension, *no*; Penn State Extension, *no*; Wentworth, *no*; Westinghouse, *yes*, by a minority. It is of interest to note that the faculties are of much the same sentiment on this issue as the graduates, although open propaganda seems largely absent.

Some administrative heads merely ignore these influences. One gives his formula as ''firmness''; another meets them ''by facts and persistence''; and a third ''by a clear statement of policy and a constant effort to orient the faculty.'' One institution meets its own needs by conducting parallel degree courses; another encourages the abler students to do more advanced work elsewhere; and a third points to a degree-granting institution in its own community. Eight directors, of thirteen, consider it an advantage for exceptional graduates to pursue more advanced study; three say *no*, one adding for emphasis ''needless provision for our graduates''; while two are not quite certain.

Alumni Attitude Toward Further Education.—The administrative heads of the several institutions were asked to deal with the question:

Do graduates express a desire for further education?

To this their replies are as follows:

"Very rarely, and for advanced work along similar lines." (Bliss.)

"No." (Chicago.)

"Tendency is for graduates to return to take additional courses." (Cleveland Y.)

"Occasionally, e.g., for Spanish." (Milwaukee.)

"Yes, to obtain a degree." (Newark.)

"Yes, to gain more intensive training." (New Bedford.)

"For subjects of a liberal character, e.g., economics, literature." (Ohio Mechanics.)

"Yes, for evening extension courses and business administration." (Pratt.)

"Advanced technical subjects." (Rochester.)

"Yes, specialized subjects." (Rutgers Extension.)

"Yes, exceptional students." (Penn State Extension.)

"Specialized training." (Westinghouse.)

J. OPINIONS OF ADMINISTRATIVE HEADS AS TO THE FURTHER DEVELOPMENT OF TECHNICAL INSTITUTES

Value as Testimony.—The experience and reflections of the directors of the technical institutes are those of partisans, peculiarly near to the situation and not always able to view it objectively or as a whole. While not a final court of appeal, they are invaluable as testimony. The answers given to a number of general questions are summarized below. It will be observed that in almost every case the answer reflects the situation locally and seeks to sustain it:

1. *In your opinion, what changes, external or internal, would improve the effectiveness of the training of an institution of this type?*

"None, so far as we know. If there were, we would adopt them." (Bliss.)

"Endowment fund allowing more equipment and instruction." (Chicago.)

"More sympathy on the part of orthodox educators." (Milwaukee.)

''Have been at it ten years, have made all the changes I know.'' (Newark.)

''More recognition of this type of training.'' (Ohio Mechanics.)

''Too long a story to be related here.'' (Pratt.)

''I would have to write your report to answer this.'' (Rochester.)

''Local city committees to advise and suggest.'' (Penn State Extension.)

2. *In your judgment would it be desirable to increase the number of institutions of this type?*

''Yes, if done effectively. It has taken one-third of a century to learn how to conduct this one.'' (Bliss.)

''There is plenty of room.'' (Chicago.)

''Every large industrial city should have a junior vocational engineering college of this type.'' (Cleveland Y.)

''Yes.'' (Milwaukee, Newark, Ohio Mechanics, Pratt, Rochester, Westinghouse.)

''Not in this State.'' (New Bedford.)

''Only in communities where interest is manifest and the number of students warrants. (Rutgers Extension.)

''Depends on city support. Demand does not allow competition between schools.'' (Penn State Extension.)

3. *In your judgment, is there danger that too many men may be trained similar to your graduates?*

''Not if they are well trained.'' (Bliss.)

''To date, no.'' (Chicago.)

''Not likely.'' (Cleveland Y.)

''No.'' (Milwaukee, Newark, New Bedford, Rochester, Penn State Extension.)

''No, not at present.'' (Pratt.)

''No danger.'' (Rutgers Extension.)

''A local over-supply might be created; on a country-wide scale—no.'' (Westinghouse.)

4. *Who should sponsor schools similar to yours? (Private philanthropy, state, city, or county school systems, industries, etc?)*

''Industry first. Subsequently many self-sustaining as Bliss.'' (Bliss.)

''Private agencies and industries.'' (Chicago.)

''Any agency capable of dealing with students on a personal basis.'' (Cleveland Y.)

''Private philanthropy; eventually state controlled.'' (Milwaukee.)

''State.'' (Newark, New Bedford.)

''Advantage in private initiative but no objection to any auspices.'' (Ohio Mechanics.)

''Any or all of these should be satisfactory.'' (Pratt.)

''Any one who will do the job.'' (Rochester.)

''State, industries.'' (Rutgers Extension.)

''Any of these.'' (Penn State Extension.)

''Public school systems in cooperation with industries.'' (Westinghouse.)

5. *Is it educationally desirable to conduct these courses as the entire program of an institution?*

''Yes, we have specialized for 36 years in doing just this one thing.'' (Bliss.)

''No, not shorter courses.'' (Chicago.)

''Students often want more advanced courses.'' (Milwaukee.)

''Yes.'' (Newark, New Bedford.)

''Some advantages.'' (Ohio Mechanics.)

''Yes, many reasons of practical efficiency.'' (Pratt.)

''No, too narrow an offering for any community.'' (Rochester.)

''No, as part of general extension program.'' (Rutgers Extension.)

''Depends on local conditions.'' (Wentworth.)

''No; wider training needed to satisfy local needs.'' (Westinghouse.)

6. *Is it financially practicable to conduct these courses as the entire program of an institution?*

''Yes, we have so demonstrated.'' (Bliss.)

''No.'' (Chicago, Cleveland Y., Newark.)

''Financially better if limited to sub-college courses.'' (Milwaukee.)

''Yes.'' (Ohio Mechanics, Rochester.)

''Yes, but needs more.'' (Pratt.)

''No, part of a general extension system to lessen overhead.'' (Rutgers Extension.)

''Yes, in cities of 80,000.'' (Penn State Extension.)

''I should think so.'' (Wentworth.)

''Yes, given a large industrial center.'' (Westinghouse.)

7. *Is it of considerable advantage to conduct these courses in a separate institution or may they be carried on with equal effectiveness in an institution more comprehensive in character?*

"Independently." (Bliss.)

"Depends on management." (Chicago.)

"More comprehensive institution." (Cleveland Y.)

"In state universities—a great need for sub-collegiate courses." (Milwaukee.)

"Perfectly possible on both counts." (Newark.)

"A comprehensive institution—*here.*" (Ohio Mechanics.)

"Never succeeded in conjunction with degree courses." (Pratt.)

"Not financially practicable, sure to fail with degree courses." (Rochester.)

"Small schools conducted by state institutions." (Rutgers Extension.)

"Separate institutions best." (Wentworth.)

"Both ways doing well in Pennsylvania." (Penn State Extension.)

"Under some Board of Directors, but with separate Department Heads." (Westinghouse.)

8. *For the courses covered by this study which time plan do you consider* (*a*) *best,* (*b*) *good,* (*c*) *fair,* (*d*) *undesirable?*

	Full-time Day School	Coopera- Day School	Evening Classes	Shortened Day Courses
Bliss	*a*	*b*	*d*	*d*
Chicago	*a*	*c*	*b*	*d*
Cleveland Y			*a*	
Milwaukee	*a*			
Newark			*a*	
New Bedford	*a*			
Ohio Mechanics	*a*	*b*	*c*	*d*
Pratt	*a*	*b*		
Rochester		*a*	*b*	
Rutgers Extension			*a*	
Penn State Extension	*b*	*d*	*a*	*c*
Wentworth	*a*	?	*b*	?
Westinghouse	*d*	*b*	*a*	*d*

9. *Is it desirable to arrange such courses as are covered by this study in a sequence of one-year units, each being fairly complete in itself?*

''One year course only.'' (Bliss.)

''Yes.'' (Chicago, Cleveland Y., Penn State Extension.)

''By all means.'' (Milwaukee.)

''No.'' (Newark, Ohio Mechanics, Pratt, Rutgers Extension, Wentworth, Westinghouse.)

10. *What are the strong outstanding points of your type of school as reflected in its graduates?*

''Our graduates have an exceptional understanding of the fundamental principles of all electrical apparatus. Careful selection before entrance insures an exceptionally high quality both as to character and ability.'' (Bliss.)

''Students stimulated to and trained for positions on a higher level.'' (Cleveland Y.)

''Exceptional ability to meet new situations.'' (Milwaukee.)

''Industry and technical background.'' (Newark.)

''Graduates have a good practical knowledge of the textile industry.'' (New Bedford.)

''Encourage graduates to be more stable, more loyal and to have a better attitude toward industrial life.''

''Increased efficiency of graduates and favorable attitude of employers toward them.'' (Rutgers Extension.)

''Develops particularly useful type of man with technical information, and practical experience; and usually possessed of drive, determination and ambition.'' (Penn State Extension.)

''They go out from the school ready to work hard, to start at the bottom and they seem to get there.'' (Wentworth.)

''Graduate is self-reliant, fitting admirably into active types of jobs.'' (Westinghouse.)

VIII. TECHNICAL INSTITUTES OF EUROPE

A. General Observations and Comparisons

Value of Comparative Studies.—There is little possibility of direct borrowing from educational systems which have grown out of economic and cultural conditions quite unlike our own. Comparative studies, however, help to establish an objective base line for self-criticism. The principal European systems of technical education, representing as they do central planning and coordination based on a definite social philosophy, may throw a strong light on the gaps existing and the values overlooked in a system of more accidental development. The European systems have arisen from intense economic competition, both within and between national populations, resulting from population pressures we are yet far from experiencing. Our own has as its background the free adaptations of a pioneer era. Technical education abroad has followed planes of social cleavage which we have no desire to reproduce. The merits of their institutions, however, stand largely apart from these incidental features. Insofar the distinctive types abroad have been evolved from clearer perception of their functions and from a desire to serve with equal effectiveness people of differing interests and circumstances, they may prove wholly compatible with American ideas of democracy. They may, in fact, draw us toward the conclusion that democratic ends are not effectively served by providing only a professional training of the university type; that we need to create a parallel ladder of more adjustable entrance and terminal levels, as means of progress for men already employed or experienced; and that we shall need suitable forms of continuative experience beyond the newly developed vocational schools.

European Systems Carefully Planned.—It is plain that technical education has never been conceived by us as a national problem or thought out as a whole. While recognized as an auxiliary arm of the economic system, it has no organic bonds with the professions and industries which it serves. The schools are essentially free and such standardization as exists is self-imposed. The several European systems, while not wholly free from accidental features, represent careful planning, based on a clearly perceived social philosophy. Their schools are much less individual enterprises than our own. Great Britain has worked her problem out under parliamentary authority by a combination of central and local control, exercised respectively by the two national boards of education and by boards of local educational authorities. France has a highly centralized system, headed by an Under-Secretary of State for Technical Education. Germany leaves the control of education to the several States, with the ministries of education responsible for the technical universities and with the ministries of commerce, together with the municipal authorities, responsible for the higher, middle and lower industrial schools. The central coordinating body is in reality a representative joint committee organized on the initiative of the *Verein Deutscher Ingenieure.*

Technical institutes in France, Germany and Great Britain were studied in some detail and visits were paid to typical schools in Belgium, Czechoslovakia, Sweden and Switzerland. In order to give a series of clear pictures, avoiding excessive detail, an extended account of the first three groups only is given, while the last two are referred to quite briefly.

Common Characteristics.—The technical institutes of Europe are for the most part admirable institutions of which we have few counterparts. These schools differ in name and organization from country to country and there is a great diversity of detail in their programs and practices, but a common warp of distinctive characteristics runs through them all. With few exceptions, they stand quite clear of the secondary schools and universities which prepare for the highly intellectual professions. They are not trade schools which aim primarily at proficiency in crafts or specific processes, nor are they preparatory schools for higher studies. Their courses are of a terminal character and are designed to prepare young men who have already become oriented to industry for well-forseen lines of progress. Their curricula are shorter and more practical than those of the university professional schools. They include only a few indispensable complements of general education and the mathematical and physical sciences are not taught as independent disciplines, but in intimate connection with their technical applications. Most of their students are not bookminded; direct processes of teaching and learning are widely employed, with much less emphasis on reading and independent study than in the universities. The greater part of the student's work, in fact, is done on school premises under direct supervision. The entire process points to the higher practical pursuits of industry rather than its specialized intellectual functions of research and analytical design.

B. French Higher Industrial Schools

National Education.—France has two distinct systems of education, each complete in itself. One is designed to transmit a cherished cultural heritage and to form an intellectual elite for the future leadership of the nation. The other prepares for citizenship at large through a substantial base of general knowledge and a superstructure of vocational training. The secondary schools, known as *lycées* and *collèges,* together with the universities and special professional schools, make up one system; the primary schools, vocational schools, higher primary schools and the higher schools of mechanic arts, make up the other. Each system has its own group of higher technical schools, the one preeminently professional in spirit and intellectual in emphasis, the other preeminently industrial and practical. A small group of engineering schools occupy intermediate ground.

The cleavage between the two systems is partly traditional and partly logical. French secondary and university education is an outgrowth of the classical and philosophical disciplines of the middle ages, to which modern studies have been joined in recent decades. It has never been conceived as a popular system but rather as a special medium of cultural transmission and of preparation for the intellectual professions. The primary system is almost wholly the work of the past century. The French have pushed the principle of distinct forms of preparation for intellectual pursuits and for practical pursuits further, perhaps, than any other Western nation. The actual line of demarkation between the two systems is largely social and financial. Families which can afford the tuition fees, and in many cases the cost of *pension* as well, send their children to a national *lycée* or a municipal *collège;* those who cannot, patronize the gratuitous *école primaire;* as a result the secondary schools serve about one-

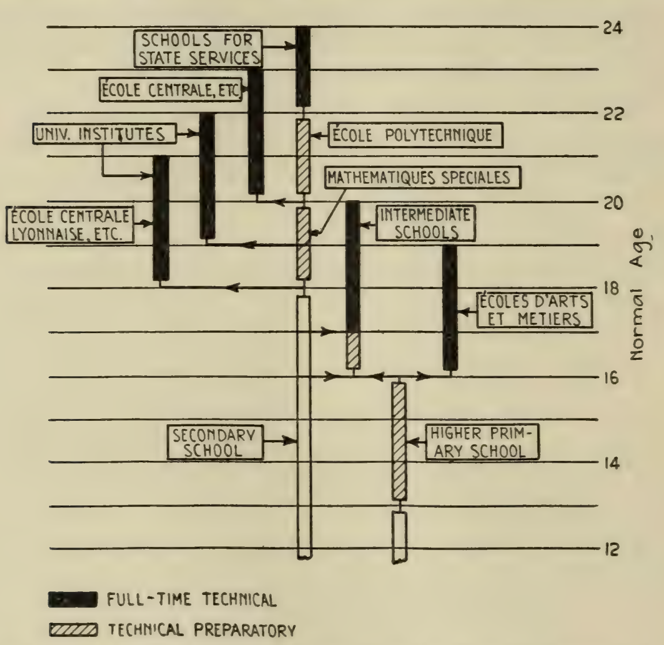

SCHOOLS FOR STATE SERVICES
ÉCOLE CENTRALE, ETC.
UNIV. INSTITUTES
ÉCOLE POLYTECHNIQUE
MATHEMATIQUES SPECIALES
ÉCOLE CENTRALE LYONNAISE, ETC.
INTERMEDIATE SCHOOLS
ÉCOLES D'ARTS ET METIERS
SECONDARY SCHOOL
HIGHER PRIMARY SCHOOL
24
22
20
18
16
14
12
Normal Age
FULL-TIME TECHNICAL
TECHNICAL PREPARATORY

FIG. 28. Technical schools of France in the systems of national education.

tenth of the population. There are bridges between the two systems at certain stages and the State maintains a considerable number of *bourses* to enable the more gifted youth to pass over from the primary to the secondary system. As one educator expressed the situation, "France assumes that her social stratification forms on hereditary lines and looks for exceptions in proportion to the Mendelian ratio."

Conflict of Ideals.—The conflict between the old tradition of a stable society with its cultural aristocracy and the newer ideals of social democracy has made the educational system a battle ground in recent decades. The rallying cry of the radicals is *"L'école unique!"*—a single national system freely open to all classes. The intellectuals, proud of the national culture and solicitous for its future, ardently defend the present dual system. The privileged classes have no desire to lose their present monopoly of favored careers. The clerical party protests unceasingly against the existing policy of secularization. The intensity of this interest, fanned by constant agitation, makes any amelioration very difficult. At the moment the first four years of the two systems are being unified, but further amalgamation seems very remote.

Primary and Vocational Education.—The primary schools of France provide a uniform program in common branches, morals, civics and physical training to the age of twelve, then ramify into various vocational branches. There are many admirable vocational schools (*écoles professionelles*) which may be entered at this stage, some under municipal and others under State auspices. Paris has fifteen such vocational schools and a special school for the training of their teachers. The trade courses for girls are usually two years in length, and those for boys three or four, according to the trade. There are also higher primary schools in the principal centers with a three-year course which begins at the age of 13 and which leads to the certificate of higher primary studies. These schools are fairly comparable to American technical, commercial and agricultural high schools. No Latin is taught, but mathematics, elementary science, modern languages, drawing and manual arts are emphasized. The students are ambitious and work hard, reaching a standard of achievement at 16 equal to that of graduation from an American high school. The technical work in drawing and shopwork is especially effective and occupies 41 out of a total of 100 year-hours in the three-year curriculum.

The best of the higher primary school are little inferior to the *lycées* in equipment and personnel and are tending to approach them in the higher parts of their program. One such school in Paris, *Ecole Turgot,* gives the complete preparation for the baccalaureate in the science-modern language section and has a special advanced section preparing for the *concours* of *Ecole Centrale.* The methods of teaching, however, are usually more intimate and freer than in the *lycées* and resemble the better practices of our own secondary schools. There are a number of *Ecoles Nationales Professionelles* which offer programs comparable to the higher primary schools, but with application to particular groups of industries such as textiles, metal working, etc. Both groups of schools offer preparation for the *concours* of admission to the six *Ecoles Nationales d'Arts et Métiers,* higher schools of mechanic arts which stand at the summit of the primary educational system and lead to the degree of *Ingénieur d'Arts et Métiers.*

The Higher Industrial Schools.—No sharp line can be drawn between the technical schools of the higher and middle categories in France. The *Ecoles d'Arts et Métiers,* although accorded recognition as higher institutions by the Ministry, actually occupy the middle level of scientific and technical instruction. Their genius lies in the realm of the mechanic arts, where they are unsurpassed in Europe. The national schools have served as models to a small group of Catholic schools and to some others under private auspices in Paris, of which the *Ecole Bréguet* is an excellent example. Apart from these groups schools of middle rank are not numerous. Strasbourg has a higher machine construction school on German lines and Mulhouse important schools of chemistry and textile technology; there is a special school for mine foremen at Alais and a school of horology and fine mechanism in the province of Doubs; and the elementary sections for electrotechnics at the universities of Grenoble and Toulouse, for paper technology at Grenoble, and for electrotechnics, public works, building construction and surveying at the *Ecole Speciale das Travaux Publics, du Batiment et de l'Industrie* at Paris practically complete the roster.

The Concours of Admission.—The competitive system of admission deserves special attention as it is peculiar to France and one of the most significant features in her national system.

While there are differences of detail from school to school, the plan of the *concours* is much the same. There are both written and oral examinations, in two stages, the first eliminatory and the second final. The *concours* not only solves the problem of selective admission but also disposes of the whole problem of student elimination and scholastic discipline in advance. French schools follow methods of mass teaching which make no allowances for individual differences and it is deemed essential that the student bodies shall be intellectually homogeneous, fully disciplined in work habits and able to follow oral instruction with great facility. The *concours* has been much criticized by French engineers and educators. The most valid charge, perhaps, is that it ignores many of the aptitudes which are essential to the engineer in favor of qualities which are more fitting to the savant than to the man of action. The present usage is so deeply rooted, however, that there is little prospect of a radical change.

Schools of the Practical Arts

The Ecoles Nationales d'Arts et Métiers.—These six institutions constitute one of the most admirable groups, not in France alone but in all Europe. As their essential purpose and character and their methods of admission have already been described, it remains only to consider their internal organization and methods of instruction. In essential matters the six schools are identical. Each serves a defined region, from which a promotion of 100 students is admitted annually. The *concours* of admission, while less intensely contested than that of the *grandes écoles,* is highly selective and assures a competent, homogeneous student body, from which there are few eliminations in course. The school at Paris, which serves only the metropolitan area, takes day students exclusively. The other five admit boarders at a very low cost. No charge is made for tuition. The students are the pick of the product of the higher primary schools, a strikingly sturdy, hard-working, intelligent and wholesome type.

Concours of the Ecoles d'Arts et Métiers.—This competition is commonly taken at the age of 16 on completion of the industrial section of the higher primary school. There are two stages: the first is a series of elimination examinations which may be taken at the chief city of each Department and in other designated centers; the second is the *concours* proper, which is held only at the *Ecoles d'Arts et Metiérs* themselves. The elimination test includes seven items, each of which has equal weight: (1) a dictation in French, followed by questions concerning its language and meaning; (2) a composition in French; (3) a test of lettering and free-hand drawing; (4) a test of machine drawing; (5) a written test of algebra; (6) a written test of geometry and of elements of descriptive geometry; and (7) a test of physics and chemistry. An average grade of 10 on a scale of 20 is required for eligibility to the *concours* proper, which includes written, manual and oral examinations with the following weights:

CONCOURS OF ECOLES D'ARTS ET MÉTIERS (1924)

Examination	Weights	
	Written	Oral
French Language	3	3
Algebra and Trigonometry	2	4
Geometry and Descriptive Geometry	2	4
Physics and Chemistry	2	4
Machine Drawing	4	
History and Geography		2
Foreign Language (Optional)	*	*
Manual Arts (performance)		5

* A majoration is allowed equal to double the excess of the grade above 12.

The following typical questions suggest the order of difficulty of the examinations:

> "A truck weighing three tons is driven at a speed of 18 kilometers per hour on a straight and level road. The truck is brought to a stop by passive friction, assumed to be constant, one minute after the suppression of the driving force. Find:
>
> *a*. The distance traversed after stopping the motor;
> *b*. The value of the passive resistance;
> *c*. The value of the propulsive force;
> *d*. What supplementary braking force must be applied to stop the truck in 30 seconds;
> *e*. What quantity of heat would then be developed in the brake?"
>
> "There is given an isosceles triangle ABC (AB = AC); a circle of variable radius is tangent to BC at B. The line AB extended cuts this circle at M and a line from M to C cuts the circle at P. Find the geometrical locus of the point P as the radius of the circle is varied."
>
> "How is the French domain of North Africa constituted? What is its economic and political importance?"

The Three-Year Program.—The prescribed course is uniform for all, except for some degree of specialization in shop practice. The program has been worked out by a ministerial commission with great care for the orientation of every item to the central purpose of the schools. The time is divided most systematically. One hour and a half of each morning is given to oral courses and conferences on scientific, technical and economic subjects. An equal period is given to specific technological instruction in shop and drafting room practice and to exercises in drawing and the laboratories. Five hours of the afternoon, excepting one half day given to military instruction and field exercises, are given over to systematic shop training on commercial production. The three divisions of the program are outlined below and the number of lessons or conferences indicated:

PROGRAM OF ÉCOLES D'ARTS ET MÉTIERS

Lectures and Conferences on General Subjects

First Year		Second Year		Third Year	
French	32	Social and industrial legislation	16	Economic history	32
Industrial hygiene	16	Economic geography	32	Scientific management	16
Algebra and analytic geometry	32	Calculus	15	Applied mechanics	34
Trigonometry	14	Descriptive geometry	14	Hydraulics	21
Applied geometry	10	Kinematics	52	Heat power	43
Descriptive geometry	40	General mechanics	18	Industrial electricity	64
Physics (heat)	32	Physics (vibrations)	10		
Chemistry	32	Metallurgy	22		
		Accounting	16		

(Provision is made for seventeen selected laboratory manipulations in industrial physics, chemistry, and metallurgy during the first and second years, and for an unspecified number of measurements and tests in the laboratory of electrotechnics during the third year.)

Lectures and Conferences on Technical Construction

First Year		Second Year		Third Year	
Masonry construction	2	Framed and concrete construction	10	Architecture of machines	5
Carpentry	5	Machine elements	22	Power machines	27
Machine elements	25				

Exercises in Drawing and Design

First Year		Second Year		Third Year	
Conventions	1	Structural framing and assemblies	3	Boiler design	2
Helix, screws, bolts	1	Metal stairway	1	Design of part of a machine tool	1
Machine parts	7	Crank rods, eccentrics	1	Design of a sample structure	2
Wooden framing	1	Pistons and valves	2	Design of a crane or hoist	2
Conic sections	1	Machine-tool parts	2	Design of a steam condenser	1
Graphs of functions	1	Cams and gears	3	Design of a pump	1
Applications of descriptive geometry	3	Applications of descriptive geometry	3	Design of an electric or gas motor	1
Plan of a building	1				

Shop Practice and Conferences

	First Year		Second Year		Third Year	
	Conferences	Weeks of practice	Conferences	Weeks of practice	Conferences	Weeks of practice
Bench and machine work	12	17	10	35*		13
Pattern making	5	6	3	9 } *	1	5
Foundry	5	6	5	26 }	4	5
Forging and heat treatment	6	6	5	35*	5	5
Electrical construction					4	4
Shop office						2
Laboratory testing						1

* Separate sections in the second year.

(The work in the shop office covers scheduling, time studies and records and cost finding. The week of laboratory tests deals with combustion and vaporization, the efficiency of prime movers and mechanisms, and the properties of materials. Electrical construction includes windings, assemblies and shop tests.)

It will be noted that the only provision for specialization is in the shop practice of the second year when the class is divided in the proportions: Bench and tool work, 55 to 80 per cent; pattern making and foundry, 15 to 25 per cent; forging and heat treatment, 5 to 20 per cent. All work done in the shops is for commercial use and up to commercial standards, but the time schedules are adapted to the pace of learners. The work done in the shop offices includes scheduling, time studies and records, and cost keeping. The laboratory tests relate to combustion and vaporization, the efficiency of prime movers and mechanisms, and the properties of materials. The period of electrical construction includes work on windings and assemblies and laboratory tests of generators, motors, transformers and meters.

In scanning the above programs it will be observed that every item has been chosen and directed to a single end—training for intelligent direction of industrial production. This spirit is carried into the individual subjects. The materials in mathematics, physics and chemistry are chosen with a direct view to their engineering utility; the courses are interconnected by problems and illustrations; yet the treatment within its limits is rigorous and in a sound scientific spirit. The work in French consists largely of composition and interpretation of texts, and is tied in with the courses in economic geography and history in the second and third years in the form of monthly written exercises in composition. The relatively great weight given to social and industrial organization will be noted.

The entire treatment of mathematics has a strong geometrical cast. The physics of the first year related entirely to applied heat and changes of state, while that of the second year deals with vibratory and radiant phenomena. The course in chemistry proceeds directly to notions of thermochemistry and chemical equilibrium, then deals with the various raw materials of industry. The laboratory exercises in physics, chemistry and metallurgy deal with such matters as high temperature measurements, tests of calorific power, measurement of gas flow, composition of flue gases, properties of lubricating oils, properties of fuels, dosage of metallurgical operations, analysis and properties of alloys, metallography and welding.

As the program is laid out on a full-time basis, with only the evenings available for preparation and reports, the teaching is necessarily of a very direct character. There is little use of textbooks and much less written work than is customary in American schools. The system assumes that the students will become men of action and execution and not professional scholars.

Equipment.—The war produced a great accumulation of surplus industrial equipment in France, and the period of liquidation which followed enabled the Ministry of Education to modernize and diversify the installations to exceptional advantage. Each plant provides simultaneous working space for the entire student body of 300, and the Paris school provides in addition for a special post-graduate year in foundry practice. The scale of installation may be judged from the fact that the shops and shop offices of the Paris school cover a floor space of more than 70,000 sq. ft. Spacious shops with complete modern equipment for commercial production are provided for wood-working, pattern-making, foundry work, forging, heat treatment, machine and bench work and electrical construction, as well as testing rooms, power plant and laboratories.

Importance of the Schools.—These schools have been in high favor with French industries for more than a century. The original school grew out of an establishment at Liancourt created in 1788 by a nobleman for the education of the sons of non-commissioned officers in his regiment of cavalry. Later the school was nationalized and transferred to Compiégne. Here Napoleon paid it a visit in 1803 and asked some of the older boys what career they planned to follow. The answer of ''soldier'' displeased the future emperor, in a mood at the moment for peaceful reforms, whereupon he addressed the school thus:

> ''The State goes to much expense to train these young men and when their studies are finished, with the exception of the military training, they are of little use to the State. Nearly all become a charge on their families when they ought to be helping them. It will be so no longer. I have just come from a visit to the great factories of the northern provinces and Paris. Everywhere I have found foremen distinguished in their art, with great skill in execution, but almost none who was able to make a drawing, the simplest calculation of a machine, or express his ideas in a sketch or in writing. There is a defect in our industry—I intend to fill it here.''

A few days later the official gazette announced:

> ''The instruction at Compiegne will have as its purpose to train skilled artisans and heads of shops''

and bestowed the name *Ecole Nationale d'Arts et Metiers.* The school was moved a second time to more commodious quarters at Chalons in 1806 and continued on the level of a trade school until 1832, when the age limits of entrance were fixed between 15 and 17 and a *concours* of admission established. The levels of entrance and instruction have been further raised at intervals with the advance of preliminary education, but the early character of a school of mechanic arts for the production side of industry has been consistently maintained. A second school of identical type was established at Angers in 1815, a third at Aix in 1843. Certain politicians sought to suppress the three schools in the budgetary crisis of 1850, but the industrialists came to their defense with such vigor that their existence has never since been threatened. At that time they were the only technical schools in France outside of Paris. Additional schools of *Arts et Metiers* were created at Cluny in 1891, Lille in 1901 and Paris in 1912 and there is a strong demand for still further additions from certain provincial centers. Their present character as schools of industrial production resembles the Worcester Polytechnic

Institute in its early years, but practical shop training is even more strongly stressed. In no other country is this type of training so definitely provided for.

At present the *Ecoles d'Arts et Métiers* supply about 40 per cent of the higher technical personnel in France and fully two-thirds of the total in mechanical engineering. They are recognized by the State as higher institutions and their graduates receive the official diploma of *Ingenieur d'Arts et Métiers.* French industry is organized on far simpler and less specialized lines than our own. Family control, handed on from father to son, still predominates. The cardinal doctrine underlying the program was stated thus a century ago, and is still largely true:

> "The science of industry is one and indivisible; every manufacturer or leader of industry must know it in its entirety or remain unequal to its tasks."

C. THE LOCAL TECHNICAL INSTITUTIONS OF GREAT BRITAIN

Introductory Resume.—Higher technical education is provided by two types of institutions, the universities and the local technical colleges. The two groups overlap and to some extent interweave, but for the most part there is a fairly distinct and effective division of functions between them. The universities have great independence and are uncompromisingly devoted to the higher intellectual interests of society; they teach the technical sciences in their universal and fundamental aspects and place a large emphasis on research, with the aim of preparing men for work in engineering and industry which requires a high standard of scientific attainment. The local technical schools form the apex of the local units of the public system of education; their activities are closely linked with the daily interests of their local populations and industries; the greater part of their work is done through part-time and evening instruction; and they aim to prepare men for the higher types of practical pursuits. In a number of instances the two functions are combined in one institution which, by affiliation with a local university, serves as a faculty of technical science and provides at the same time the widest range of practical and intensive instruction.

The distinction between an intellectual and a practical emphasis also exists in preparatory education, but is nowhere carried to such extreme limits as in France and Germany. One of the most cherished ideals of British industry is expressed in the phrase "vertical mobility." The technical crafts and professions are not sharply segregated and a continuous ladder of opportunity rises through them all. While precise data are lacking, it is certain that by far the greater part of the recruitment of technical occupations comes from apprenticeship and the local technical schools. The total enrollment of matriculated students of the technical sciences

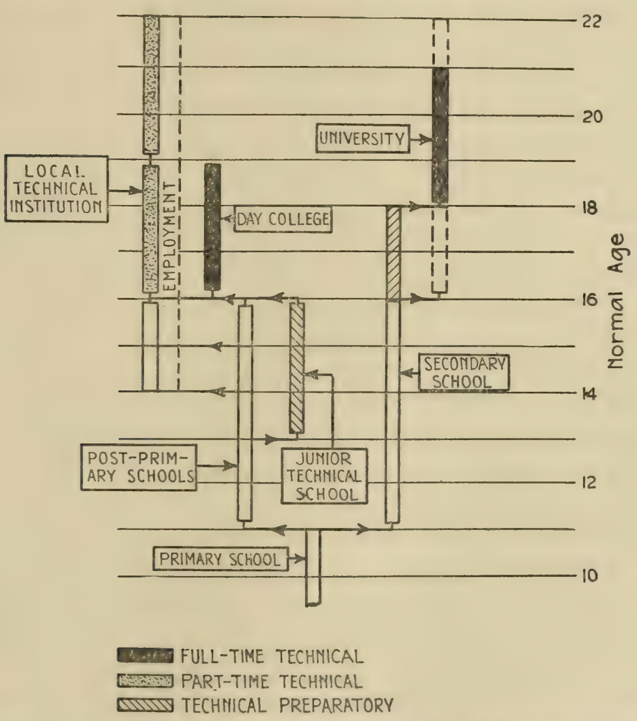

22
20
UNIVERSITY
LOCAL TECHNICAL INSTITUTION
EMPLOYMENT
DAY COLLEGE
18
16
Normal Age
SECONDARY SCHOOL
14
POST-PRIMARY SCHOOLS
JUNIOR TECHNICAL SCHOOL
12
PRIMARY SCHOOL
10
FULL-TIME TECHNICAL
PART-TIME TECHNICAL
TECHNICAL PREPARATORY

FIG. 29. Provision for technical education in the English system.

in all of the British universities does not exceed 3,000 and the number of first degrees awarded does not reach 600 per year, while in the London county area alone there are more than 7,500 enrolled in evening and part-time classes in engineering. The total for Great Britain is probably at least four or five times that figure.

While other countries provide for much larger numbers of full-time university students, none approaches Great Britain in providing for such a large proportion of young engineers so adequate a technical education concurrently with self-support and the acquirement of industrial skill and experience through apprenticeship or otherwise. For the great majority economic conditions make some such system the only possibility of gaining a good technical education. It is not to be assumed, moreover, that a part-time technical education is necessarily inferior to a full-time course; it not infrequently covers 5, 6, or 7 years after the age of 16, with an attendance of perhaps 200 hours per year in evening classes, but the result of diligent work out of classrooms and concurrent experience in industry often carries the student to a standard of knowledge as high as that reached by three years of attendance at a university. There are many highly placed engineers who, quite apart from economic considerations, prefer part-time education to full-time courses as the best possible form of engineering training.

The limitations of evening instruction, even at its best, are severe and there is now a vigorous movement, backed by the national Board of Education, for the wider introduction of part-time day courses to which employers may send engineering apprentices for two or three half-days per week. The number already enrolled exceeds the total of university enrollments in engineering by more than 50 per cent and is increasing rapidly. In the best informed English circles, both private and official, this movement is believed to hold the center of the main highway of educational progress.

Education for Adolescents.—The outstanding deficiency of English education has been the totally inadequate provision for the adolescent years. Official reports for 1919–20 showed less than sixty per cent of the age group from 11 to 18 to be receiving either whole- or part-time education and less than six per cent provided for in secondary schools. More recent data, for 1924–25, indicate that out of a total of 100 of English youth attending primary schools 35 continue their full-time education beyond the compulsory lower age limit of 14, but that only 12 of this number enter the secondary school and only 1 the university. These facts emphasize the great importance of higher continuative education and explain the abundant provision made for it in the local technical school which forms the apex of each local school system.

The plan which is now emerging from the former chaos assigns the period between the ages of 5 and 11 plus to the primary school and makes a distinct break at the threshold of adolescence. Here the paths divide: one leads through the secondary school and the university to public life or the distinctly intellectual professions; the other leads through a group of post-primary schools of three types and the higher forms of continuative education into the more practical pursuits.

At the end of the primary period there is to be a careful appraisal of the abilities and interests of the pupils as a basis for their distribution. A large group will then pass to a non-selective "senior school" with a three or four years' course; a smaller group to a semi-selective "central school" with a four or five years' course; and a much smaller number to a highly selective "secondary school" with a six or a seven years' course. The curricula of the senior and central schools are independent of university control and stress modern studies—history and geography, living languages, mathematics and science. Neither school has a distinctive vocational character, but a "practical bias" may be introduced in the third or the fourth year. Vocational training in preparation for engineering, trades, or business apprenticeship is given in the "junior technical school," to which the pupil may transfer at the age of 13. The program of the secondary school proper conforms to university standards and is purely non-vocational, but usually has a ''classical'' and a ''modern side,'' which of late have tended to approximate equality of numbers and prestige.

The Scottish Educational System.—Scotland has always been small in population and poor in resources, but nowhere have the benefits of education been more highly valued or more eagerly sought. There is an intensity in Scottish education which England can not match. Scotland has long had a fully articulated system of public primary, secondary, continuation and technical schools and her universities, while autonomous in government, are essentially public institutions. The system as a whole may be pictured as a common base of primary studies extending to the age of 12, from which two ladders ascend to higher levels—one through the secondary school and the university, the other through the upper primary school, the local continuation school and the central institution for advanced day and evening technical studies. In 1924–25 the enrollment in the lower primary schools was 81.7 per cent of the total school population, with 8.7 per cent in the higher primary schools and 9.6 per cent in the secondary schools proper. Again the great importance of higher continuative education for the many denied secondary and university education should be noted.

Local and Central Technical Schools.—The coordination of local and central evening classes is the most distinctive feature of Scottish technical education. The local continuation schools provide instruction in both individual subjects and grouped courses for those who leave the upper primary schools at 14 or 15. The courses extend two years or longer according to the size of the community. The more promising students are transferred at one or more stages to a regional central institution, with travelling expenses paid, for more advanced and specialized work. Three of the five central institutions also conduct day technical colleges where both diploma and degree courses are offered. The evening and day courses are closely coordinated and the evening student of unusual ability may obtain a public bursary to aid him to undertake full-time work. Thus, with wise economy of resources, Scotland has realized Huxley's ideal of "an educational ladder, reaching from the gutter to the university, up which any child may climb as far as his abilities will take him."

The four Scottish universities have distinct chairs or departments of engineering and give considerable instruction on their own account, but the affiliation of the Royal Technical College, Heriot-Watt College and Robert Gordon College with the neighboring universities at Glasgow, Edinburgh and Aberdeen creates an intimate bond between the two systems of higher education. Through reciprocal course schemes the duplication of equipment and instruction is kept to a minimum. The three affiliated colleges, however, do not limit their day instruction to degree courses but cover a most comprehensive field. None of the evening courses are regarded as university work, although some of them reach a relatively high standard.

The Junior Technical School.—The American equivalent of the junior technical school is a vocational high school giving a three years' course preparing for industrial apprenticeship. The course normally covers the period from 13 to 16 years of age. Most of the pupils transfer from the higher primary schools and ex-secondary pupils are rare. Many of the junior technical schools are divisions of local technical institutions and have the use of their extensive laboratory, shop and recreational facilities, but are under the direction of their own principal and staff. There are two quite distinct types of schools, one giving a rather general curriculum in mathematics, science, English, drawing and manual arts preparatory to engineering trades, and the other giving more specific craft instruction, principally for the building trades. In the greater London area there are thirteen junior technical schools with twenty-two different courses in thirteen trade groups. Seven of these schools, with about half of the total enrollment, prepare for the engineering trades. England and

Wales had 74 junior technical schools recognized and aided by the Board of Education in 1924–25, with a total enrollment of 10,141.

While these schools prepare for direct entrance to industry, their work is an admirable preparation for the "senior courses" of the technical institutions, where the graduates commonly take the part of pacemakers. As there is no leavening examination to impose an arbitrary standard the better junior schools have shown a refreshing zeal in breaking away from routine academic methods little suited to the mechanically-minded boy. The teaching is very direct; oral, written and practical work are closely interconnected; and new principles are immediately exemplified in the laboratory, shop or drafting room. In mathematics, for example, functional relations and rate concepts are introduced from the beginning and graphical and analytical methods are constantly tied together, so that the student at 16 has some real insight into the nature and practical significance of differentials, derivatives, maxima and minima—an achievement which moves an American observer to mixed envy and despair! English, including history and geography, carries the humanistic load, with French sometimes offered as an alternative to part of the shop-work for those who aim ultimately to reach a matriculation standard. The thirty-hour week of attendance is common, with an additional hour and a half a day of home work. The program of the pre-engineering schools ordinarily gives five clock hours per week to mathematics, physical sciences, English and drawing respectively, six hours to shop work and one to gymnastics. The schools are intimate, the teachers and boys unusually keen and the morale excellent.

Complementary junior courses, consisting of two years of evening work, are given by the local technical schools in order to equalize the preparation of pupils from other forms of post-primary schools before their admission to the senior technical courses.

Function of Apprenticeship.—British engineering is an outgrowth of handcraft and technical education is regarded

APPRENTICESHIP AND RELATED TECHNICAL EDUCATION IN ELECTRICAL ENGINEERING

Grade of Worker	Previous Education	Duration of Specialized School or College Course in Years	Age on Entry to Works	Period of Training in Works in Years	Subsequent Position in Works	Education Concurrent with Works Training	Duration in Years of Part-time Day or Evening Courses
A. Unskilled and semi-skilled.	Elementary	—	14	Various	Laborers, unskilled and semi-skilled workers.	(*a*) Day Continuation Schools. (*b*) Evening Classes.	2 2 or 3
B. Trade Apprentices.	Elementary Higher Elementary Junior Technical Secondary	— — 2 or 3 years after Elementary. —	14 15–16 15–16 16	5 years from age of 16	Skilled workmen in all branches, charge hands, leading hands, inspectors and foremen.	Part-time day or evening courses of Minor grade; or in particular cases of Major grade as below.	2 or 3
C. Engineering Apprentices.	Elementary and Secondary, up to Matriculation Standard.	—	16–18	4 or 5 years from age of 16 or 17	Positions in drawing office, works, test room or on engineering, commercial or erecting staffs.	Part-time day or evening courses for National Certificate in Electrical Engineering: Ordinary grade Ditto: Higher grade.	3 2
D. Student Apprentices.	University or Technical College.	3–4 subsequent to Secondary.	19–22	2 or 3 years for graduates	Foremen, senior positions in drawing office or works, or on engineering, commercial or erecting staffs.	Part-time day or evening courses for National Certificate, Higher grade.	2
E. Research Apprentices.	University	1 year subsequent to graduation.	22	1–2	Staff positions in Research Department of works.		

as the modern substitute for part of the mediaeval system of indenture. In keeping with tradition apprenticeship is the common warp which runs through all the processes of technical education and unites them into a common fabric. All the formal processes of teaching and learning from the junior technical school to the postgraduate schools of the universities are regarded as adjuncts to systematic practical training.

The ideal of "vertical mobility" has always been dear to British engineers and industrialists, and the scheme of graded apprenticeship with supplementary evening classes in local technical schools is the ladder up which a large proportion of the ablest engineers have climbed to high responsibility. The universities supply only a fraction, probably between one-tenth and one-fifth, of the higher technical personnel and are constantly pressed to keep their instruction on the highest scientific level. The division of function between apprenticeship, local technical school and university is on the whole a fortunate one.

Forms of Apprenticeship.—An excellent example of the graded apprenticeship system may be taken from the field of electrical industry, as outlined in the accompanying table.

Internal works schools for trades apprentices are maintained by some of the largest concerns. Engineering apprentices, who are being recruited increasingly from the secondary schools, are expected to extend their education in the local technical schools. An increasing number of concerns are requiring apprentices of this class to attend part-time day classes and pay them at the regular rate for time so occupied. The premium system is not yet extinct, but is moribund. All classes of apprentices now receive nominal wages. Student and research apprentices usually receive about the cost of simple maintenance, but the junior groups who are presumably living at home get much less.

Examples of Apprentice Training.—(*a*) The system of training followed by the Admiralty has many interesting features. Apprentices are chosen by examination between the ages of 15 and 16 and serve five years. In four years of the course they attend special dock-yard schools six hours per week during working hours and six hours on their own time for forty weeks in the year. Annual examinations determine the promotion from year to year. The highest ranking apprentices are sent to the Royal Naval College at Greenwich to be trained as naval constructors and as electrical engineers. The Corps of Naval Constructors, which is probably the most eminent group of its kind, is principally recruited from this source. (*b*) The schedule pursued by student apprentices who enter the Royal Ordnance Factories from the higher technical institutions and universities is fairly representative of industrial practice. It comprises twelve months of machine work, twelve months of fitting, erecting and mill-wright work, nine months in the pattern shop, foundry and forge and three months in the drawing office, with a normal working week of forty-seven working hours.

Order of Practical and Scholastic Training.—No question in the history of British technical education has been debated more heatedly than the order in which the scientific and the practical parts of the training shall be arranged. Strong partisans may be found for each of the following plans (1) works-school, (2) school-works, (3) works-school-works, (4) school-works-school, (5) sandwich and (6) internal school shop for commercial production. All seem to have worked reasonably well. The White report advised that a "preliminary workshop course" of one year should be taken before entering the university or technical day college and the apprenticeship be completed by two years of more specialized experience after graduation. Many of the universities advise and one or two require a year's experience before admission.

The Sandwich Plan.—By this plan the college session occupies the six winter months and the remainder of the year is left free for industrial experience. It originated in Glasgow, where the climatic conditions particularly favor this division of the year, and remains in strong favor with the college and the industries alike. The University of Sheffield offers a similar program as an alternative to its usual course. The University of Bristol has a sandwich plan based on a program of 10 months in college, 14 months in works, 10 months in college, 2 months in works, 10 months in college and a final 14 months in works. Faraday House, a private college of electrical engineering in London, gives a four-year course, the first and third years being spent in college and the second and fourth in practice. Northampton Polytechnic, London, has a four-year course and places its students in cooperating work for six months in the second and third years respectively. The sandwich plan in its purity, however, was characterized by one of its leading exponents as ''a plan which enables indentured apprentices to attend college half of the year, something quite unlike the cooperative plan by which the college provides its students with collateral experience.''

The Internal Shop School.—Loughborough College is the active exponent of practical training in the internal school shop for commercial production. It gives five-year courses in mechanical, electrical and automobile engineering; during the college session of ten months the student spends alternate weeks in classes and in the production shops, with the option of an additional month of shop experience in the summer. The principal, Dr. Schofield, is an enthusiastic supporter of the plan. The general opinion, however, is that the establishment is too small and too special to give the full equivalent of industrial experience in a normally organized industry.

Local Technical Schools.—The apex of each local system of schools—municipal, borough or county—is a local technical institution whose chief function is to provide the higher forms of continuative education. There are more than 200 such institutions in England alone. The outstanding quality of these schools is their complete adaptation to local needs. In some small borough one may find the school in a made-over building with the simplest of rooms and equipment, presided over by a single full-time teacher who enlists the part-time service of intelligent local craftsmen and technicians in giving a modest group of evening courses in drawing, elementary science and trade subjects. A large industrial center may boast a vast polytechnic institution with elaborate laboratories, shops and ateliers, a highly qualified professional staff and many auxiliary craft teachers, a wide range of courses from trade to university standards in both day and evening classes, and an enrollment running into the thousands. The London County Council has a fully coordinated group of twenty or more technical schools under its direction, some for specific industries such as printing and building, others of the broadest polytechnic type, the whole covering the entire range of technical instruction from junior to university courses.

This admirable variety is the result of a happy combination of national aid and local direction. Half of the support comes from the national Board of Education, whose inspectors guarantee the efficiency and standards of the schools and exercise an invaluable advisory influence, but the real direction comes from the local education authorities. In many cases there are advisory committees or auxiliary associations representing the local industries. Throughout England, except in the greater London area, each institution is self-contained. The connection between the local continuation schools and the central institutions in Scotland has already been described.

Relations with Universities.—Five technical institutions in large cities, Bristol, Manchester, Aberdeen, Edinburgh and Glasgow, combine the functions of a university faculty of technology and of a local school of continuative education. The same is virtually true of three London polytechnics, Battersea, Northampton and Regent Street, which have "recognized teachers" of the University of London and prepare day students for the "internal degrees." A large number of the larger local institutions which have no formal university affiliations include in their offerings both full-time and evening courses of university type and standard which lead to diplomas or to the external degrees of the University of London. These conditions make it impossible to divide British technical education into sharply defined university and non-university types. The essential difference is often a matter of intangibles—the atmosphere, traditions, corporate life, scholarly tone and research spirit—rather than the course of study. Where the university is independent and uncompromising in its loyalty to intellectual ideals, the local technical college is flexible, responsive to local interests, and adaptable to the student on the level of his conscious practical needs.

While precise data are lacking, the local technical colleges are unquestionably the chief source of recruitment and training for the technical occupations. The total enrollment of men and boys in evening technical schools in England and Wales for the year 1926–27 was close to 390,000, with an additional 11,000 in day continuation classes and an equal number in junior technical schools. Many of these numbers, of course, were enrolled in trade courses or in relatively elementary subjects. However, there were more than 4,000 engineering apprentices enrolled in part-time day courses and nearly an equal number in full-time post-secondary courses. The work of these schools is rightfully regarded as one of the major factors in British industrial leadership.

Types of Instruction.—The ideal of adaptability to individual and local needs has led to a wide variety of types and levels of instruction, as follows:

FULL-TIME COURSES

- Junior technical schools:
  - Pre-engineering courses
  - Craft courses
- Day technical colleges:
  - Engineering courses
  - Science courses
  - Technological courses

EVENING AND PART-TIME COURSES

- Preparatory courses
- Junior courses
- Minor courses in crafts
- Major courses:
  - Engineering } { Senior
  - Technological } { Advanced

Evening courses in elementary subjects are classed as "preparatory"; the "junior" courses in evening schools are of two years' duration and are suitable for those who left the day school at 14; "senior" courses are of two or three years' duration and are suited to those who have completed a junior course and to those who have left the day school at 15 or 16; "advanced" courses are suited to older students and reach, within the limits covered, the standards of university work. Major courses extend through both the senior and the advanced stages, while minor courses are confined to the senior stage alone. A minor course usually prepares for some skilled craft within an industry while a major course is related to the industry as a whole or to the higher posts in any part of it.

A clear distinction is drawn in Great Britain between engineering courses, which prepare for activities relating to the design, manufacturing and utilization of machinery and to civil construction, and courses in the technology of specific industries, such as textile manufacturing, printing, coal mining and the like.

Examples of the Range of Instruction.—Four examples have been chosen to illustrate the range of instruction offered by the local institutions. The Municipal Technical College of Huddersfield, an important textile and engineering center, is one of the largest schools not affiliated with a neighboring university as a faculty of technology. The Municipal Technical School of Lincoln, a city of about 40,000 with some important manufacturing interests is of much more modest proportions. The Manchester Municipal College of Technology is the most conspicuous, perhaps, of the university affiliated schools as well as the largest and most comprehensive of the local institutions. The London County Council School of Building at Brixton, represents the monotechnic type of institution.

TECHNICAL COURSES OF A LARGE LOCAL INSTITUTION (HUDDERSFIELD)

Major Part-Time and Evening Courses

(S denotes the senior and A the advanced grade.)

Course	Years and Grade	Credentials	Course	Years and Grade	Credentials
Woolen Yarn	3S, 2A	Dip.	Dyeing	4S, 2A	Nat. Cer.
Worsted yarn	3S	C.&G. Cer.	Civil engineering	3S, 2A	
Weaving and designing	3S, 3A	Dip.	Mechanical engineering	3S, 2A	Nat. Cer.
Cloth finishing	4S, 1A	Cer.	Electrical engineering	3S, 2A	Nat. Cer.
Textile mfg.	3S, 3A	Dip.	Building	3S, 2A	Dip.
Loom tuning	4S	Cer.	Plumbing	3S, 2A	Cer.
Chemistry	4S, 3A	Dip.; Deg.	Coal mining	6S, 6A	Dip.
Gas engineering	3S, 2A	Nat. Cer.			

Minor Evening Courses

Breadmaking	3	C.&G. Cer.	Ironfounding	3	Cer.
Confectionery	3	C.&G. Cer.	Woodworking	2	
Mechanical engineering	4	Cer.	Carpentry	3	Cer.
Pattern making	3	Cer.	Electrical workshop	3	Cer.
Motor engineering	4	Cer.	Telephony	4	C.&G. Cer.

Full-Time Day Courses

Chemistry	3	Dip.; Deg.	Electrical engineering	3	Dip.; Deg.
Dyeing	3 or 4	Dip.	Science	3	Dip.; Deg.
Wool textiles	3	Dip.	Architecture	3	Cer.
Civil engineering	3	Dip.; Deg.	Architecture	2 Adv.	Dip.
Mechanical engineering	3	Dip.; Deg.	Commerce	3	Dip.

Courses Given by a Smaller Local Institution (Lincoln)

a. Secondary Day School for boys; 7-year course; 380 enrolled.
b. Day and Evening School of Art; 160 enrolled.
c. Part-Time Day School for Mechanical Engineering Apprentices; 2-year course, advanced grade; 67 enrolled.
d. Evening Engineering, Science and Commercial Classes; 800 enrolled.
  Mechanical engineering, junior course, 2 years (14–16)
  Mechanical engineering, minor course, 2 years (16–18)
  Mechanical engineering, senior course, 3 years (16–19)
  Mechanical engineering, advanced course, 2 years (19–21)
  Motor car engineering, minor course, 1 year
  Electrical engineering, senior course, 3 years (16–19)
  Telegraphy and telephony, minor course, 1 year
  Course for apprentice chemists, 1 year
  Matriculation subjects
  Subjects for intermediate examination (London)
  Junior commercial course, 1 year
  Senior commercial course, 3 years

Part-time Day Courses for Apprentices

Wood Machine Work, 2 years
Letter Press Composition, 2 years
Machine and Press Work, 2 years
Lithographic Printing, 2 years
Photo-mechanical Processes, 2 years
Book-binding, 2 years
Pharmaceutics, 3 years
Plumbing, 3 years

Evening Courses in Craft Subjects

Carpentry and Joinery, 3 years
Cabinet Making, 3 years
Photography, 2 years
Photo-engraving, 2 years
Photo-lithography, 1 year
Typography, 4 years
Machine and Press Work, 4 years
Lithography—Drawing, 4 years
Lithography—Printing, 4 years
Book-binding, 4 years
Breadmaking, 3 years
Flour Confectionery, 3 years
Foundry, 2 years
Plumbing, 5 years
Sanitary Inspection, 3 years
Mine Firemen, 1 year
Mine Undermanagers, 2 years
Mine Managers, 1 year

SUMMARY OF COURSES, MANCHESTER MUNICIPAL COLLEGE OF TECHNOLOGY

Degree or Credentials	Curricula	Basis of Admission	Day or Evening	Length Years	Hours per week
Ph.D.	Elective	B.S. or M.S.	Day	2 (min.)	
M.S. Tech.	Elective	B.S. or special	Day or part time	1 (min.)	
B.S. Tech. Honours: 1st class 2d class 3d class Ordinary	Mech. Eng. Elec. Eng. Mun. & Sanitary Eng. App. Chem. (10 options) Textile industries (5 Options)	Higher certificate for honours Matriculation for ordinary degree	Day	3	26 to 37
Certificate in Technology	Same as for B.S. Tech., also Photography	Entrance examination	Day	3 2	26 to 37 30
Certificate with Distinction	Advanced in above branches	Certificate in Technology	Day	1	
Ordinary National Diploma	Mech. Eng. Elec. Eng.	Min. age 16 and examination	Day	2	28
Non-degree courses	Mun. & Sanitary Eng. Textile Industries Chemistry of Textiles	Min. age 16 and examination	Day	2	27 to 31
Ordinary National Certificate for Senior courses	Mech. Eng. Elec. Eng.	Min. age 16, school certificate and related employment	Day (1 per week) or Evening (3 per week)	2 2	7 6½
	Chemistry and Chem. Technology (6 options)	As above, and 1-year prelim. course	Evening (3 per week)	2	7

Degree or Credentials	Curricula	Basis of Admission	Day or Evening	Length Years	Hours per Week
Associateship and higher National Certificate	Mech. Eng. Elec. Eng. Chemistry and Chem. Technology (6 Options)	Ordinary National Certificate	Day or evening Evening	2 2	7 7
Associateship	Steelwork Reinf. Concr.	Min. age 16, School Certificate and related employment	Day and evening (1 per wk.)	3	9
Intermediate Course Certificate	Munic. Eng. Sanit. Eng. Bldg. Surv. Heat. & Vent. Build. Const. Struct. Eng. Cotton Spin. Cotton Manuf.	Min. age 16, School Certificate and related employment	Evening	2	7
Associateship and Advanced Course Certificates	Munic. Eng. Sanit. Eng. Bldg. Surv. Heat. & Vent. Build. Const. Quant. Surv. Reinf. Concr. Textile Des. Cotton Indus.	Intermediate course as above	Evening	2	7
Certificate	Indus. Adm. Indus. & Soc. Welfare	Evidence of secondary education	Day	2	33

SUMMARY OF COURSES, LONDON COUNTY COUNCIL SCHOOL OF BUILDING

a. Junior Day School. Pre-apprenticeship craft courses, entered at 13:

Brickwork
Masonry
Carpentry and Joinery
Plumbing
Painting and Decorating
Plastering

b. Senior Day School. Course, 3 years; entered at 16, with lower school certificate; technical preparation for leading positions in the building industry; principal subjects are Architecture, Building Construction, Mathematics, Drawing, Chemistry and Physics of Materials, Mechanics of Building, Quantity Surveying, Reinforced Concrete, Structural Engineering.

c. Evening School:

Major courses, preparing for professional examinations, 6 hours per week:

- Building Construction and Drawing, 5 years
- Quantity and Building Surveying, 5 years
- Valuation and Land Surveying, 5 years
- Structural Engineering, 4 years
- Architecture and Drawing, 5 years

Trade courses, each 6 hours per week:

- Brickwork, 3 years
- Masonary, 3 years
- Carpentry and Joinery, 4 years
- Plumbing, Pipe Fitting and Welding, 4 years
- Heating and Ventilating, 2 years
- Plastering, 3 years
- Painting and Decorating, 3 years
- Wood Machine Work, 3 years

Credentials for Non-Degree Courses.—It is practically hopeless for the British student, however promising, to seek employment or advancement ''on his face'' alone; he is certain to be asked for his formal credentials; hence the universal importance attached to ''leaving examinations'' attested by some certifying agency of unquestioned authority. The university degree fulfills this function in its own field, but is very closely guarded. The immense development of other forms of technical education has called forth other appropriate forms of credentials of national significance, which taken together with the university degrees make up a veritable system of educational currency. The weight behind these credentials depends upon the authority which gives or certifies the underlying examinations. The numerous examining agencies fall into five groups (1) the universities, which administer the lower and higher certificate examinations in the secondary schools and examine candidates for degrees; (2) the chartered professional institutions of engineers, chemists, architects, accountants and the like, which examine candidates for their several grades of membership and for other professional certificates; (3) the City and Guilds of London Institute which examines for certificates in various technological crafts, the Royal Society of Arts which examines for certificates in commercial branches, and similar quasi-public agencies; (4) regional associations of educational authorities which provide leaving examinations in junior and minor courses in technical institutions in their areas; and (5) the more important technical colleges, which examine for their own associateships, diplomas and certificates.

The strictly external examination has a strong traditional basis, and is still exemplified by the lower and higher certificate examinations in the secondary schools. The examinations within the universities have tended to become essentially internal, though usually subject to moderation and review by an ''external examiner'' from some other institution. The best teachers feel hampered in their handling of their subjects and unable to fit their teaching to individual needs under the extreme external type; one must do what will ''pay in the examination room'' and there is often failure to take due account of certain qualities of the highest value, such as sustained application and the ability to work independently. The internal examination is admittedly effective in the hands of professional teachers, though lacking in objective quality, but is not considered a sufficient guide for part-time teachers with little training in the arts of teaching and examining. In such cases a syllabus and examination set by an external agency is generally regarded as a necessary guarantee of attainment.

National Certificates and Diplomas.—In recent years a most satisfactory scheme of examinations and credentials has been developed under the joint auspices of the English and Scottish Boards of Education and a group of professional institutions. National Diplomas in Mechanical Engineering, Electrical Engineering, Chemistry, Naval Architecture and Gas Engineering are given for successful examinations following full-time day courses, and National Certificates for examinations following evening and part-time courses. Both are given in two grades, "ordinary" for senior courses and "higher" for advanced courses, and are normally taken in succession. The examinations are held only in schools specially approved as regards equipment, staff and curriculum, but without narrow prescriptions. The papers are set and the books graded by the local teachers but in the final year of the senior and of the advanced courses the teachers are associated with assessors, appointed by the respective professional institutions, who moderate the papers and revise the grading. Credit is given for home work, class work, practical exercises and attendance, as well as for examination grades. The assessors give only nominal attention to the clear cases of success or failure, but review the border line cases with detailed care. The expense of this supervision is met by a nominal examination fee for each student; the cost per paper moderated is about $5 and per script assessed about 25 cents. The success of this plan in combining freedom for the teacher, latitude for the school to fit its courses to local needs and the guarantee of a professional body of the highest repute has been notable. There is an active demand for the extension of the plan into other fields, especially that of building construction.

The plan has been most largely developed in the field of Mechanical Engineering where it was first introduced in 1922. Taking the examinations and awards of the year 1927 as an illustration of the scope and working of the plan in England and Wales:

DATA ON NATIONAL DIPLOMAS AND CERTIFICATES IN MECHANICAL ENGINEERING, 1927

Credentials	Schools approved	Schools participating	Candidates examined	Candidates passed	Passed, per cent
Ordinary certificate....	108	92	1,150	593	51.5
Higher certificate......	52	42	340	239	70.2
Further endorsement...		3	17	17	100.0
Ordinary diploma......	12	6	42	29	69.0
Higher diploma........	7	5	36	31	86.1
			1,689	909	(av.)53.8

As an indication of the relative importance of these credentials, it may be noted that the total number of university degrees in mechanical engineering and mechanical science for England and Wales in 1927 probably did not reach 250.

Certificates in Technology.—The chief certificating agency for craft and technological branches is the City and Guilds of London Institute, maintained, as its name implies, by the ancient "livery companies" which in medieval times regulated craft apprenticeship. Its examinations are wholly "external," but are set and assessed with the advice of committees representing the respective trades, industries, teachers, and schools concerned. The syllabuses are elaborated in considerable detail and exercise a controlling influence on the teaching of technological and trade branches, particularly in the textile field. Most of the examinations are given in two stages, leading to preliminary and full technological certificates, respectively. The prospectus of the Institute lists 99 separate branches for which certificates are granted, 7 of which are of an engineering character and 26 are various branches of textile technology. In 1927 the Institute gave examinations in 85 subjects at 354 examination centers; 11,308 candidates were examined and 7,051 received passing grades. The City and Guilds Institute is the most important certificating agency for teachers of craft subjects. Before the establishment of the National Certificates and National Diplomas its examinations in engineering branches were of much greater importance. The work of the Institute extends throughout the British Empire.

College Diplomas, Certificates and Associateships.—The larger technical colleges prefer to give non-degree graduates credentials which identify them with the local institution rather than some remote examining agency. Three forms are commonly used, the diploma, the certificate and the associateship, but there is no uniformity of usage and each carries the degree of prestige that the name of the college can give it. The Imperial College of Science and Technology, London, makes its associateship the normal objective of its courses and the degree of the University of London an optional auxiliary. Manchester, as shown on page 173, stresses the degree as a primary objective, awards a certificate in technology to non-degree graduates of its day courses, and uses the associateship as a form of local credentials for the advanced evening courses. Loughborough College conducts courses which meet the external degree standard of the University of London and gives a diploma as its primary award and an associateship as an award of lower standard. The Royal Technical College, Glasgow, makes the diploma in engineering science its normal objective, for three-year day courses and the university degree an optional objective after a four-year course. Holders of the diploma who have had approved practical experience, may qualify for the associateship by a fourth year of studies; degree men, with approved practical experience, may qualify for the associateship by presenting an advanced thesis giving evidence of knowledge of methods of research. In short, the university degree, the National Diplomas and Certificates, the City and Guilds Certificates in Technology and the grades of membership of the professional institutions have a definite, nation-wide significance, but other forms of testimonial are of widely variable significance.

Examples of Curricula.—The examples chosen below are from the evening and part-time courses of senior and advanced grade. The full-time day courses, as a rule, do not differ significantly in form from those of the universities:

Course in Mechanical Engineering for the National Certificates

(Municipal Technical College, Halifax)

Senior Course in Mechanical Engineering

Subject	Hours per week		
	First Year	Second Year	Third Year
Practical mathematics	$2\frac{1}{6}$	$2\frac{1}{6}$	$2\frac{1}{6}$
Engineering science	$2\frac{1}{6}$	$2\frac{1}{6}$	$2\frac{1}{6}$
Engineering drawing	$2\frac{1}{6}$	$2\frac{1}{2}$	$2\frac{1}{2}$

ADVANCED COURSE

	Fourth Year	Fifth Year	Sixth Year
Practical mathematics	$2\frac{1}{6}$		
Mechanics and hydraulics	$2\frac{1}{2}$		$2\frac{1}{2}$
Heat engines	$2\frac{1}{2}$	$2\frac{1}{2}$	
Machine design		$2\frac{1}{2}$	
Materials and structures		$2\frac{1}{2}$	
Economics of engineering			$2\frac{1}{6}$
English and French			$2\frac{1}{6}$

The examination for the higher national certificate is taken at the end of the fifth year, but an additional endorsement may be gained by the work of the sixth year, which also completes the preparation for the Associate's examination of the Institution of Mechanical Engineers. The mathematics of the senior course covers selected aspects of algebra, geometry, trigonometry, graphic representation and simple calculus. The advanced course adds certain complements of algebra and trigonometry, but consists mainly of calculus and its engineering applications. Engineering science is a composite course based principally on mechanics and heat, with applications and laboratory exercises on mechanical systems, materials, and simple engines. The technical courses of the advanced period each include their complement of laboratory work or drawing.

COURSE IN ELECTRICAL ENGINEERING FOR THE NATIONAL CERTIFICATES

(Borough Polytechnic Institute, London)

SENIOR COURSE

	Hours per Week		
	First Year	Second Year	Third Year
Practical mathematics	2	2	2
Electricity and magnetism	$2\frac{1}{2}$		
Mechanics and heat	$2\frac{1}{2}$		
Engineering drawing		$2\frac{1}{2}$	
Electrical engineering:			
Units, measurements, d.c. circuits		$2\frac{1}{2}$	
Materials, d.c. machines			$2\frac{1}{2}$
A.C. circuits			$2\frac{1}{2}$

ADVANCED COURSE

	Fourth Year	Fifth Year
Practical mathematics	2	
Electrical engineering:		
A.C. machines	$2\frac{1}{2}$	
Laboratory	$2\frac{1}{2}$	
Calculation of machines		$2\frac{1}{4}$
Generation, transmission, distribution		$2\frac{1}{4}$
Laboratory		$2\frac{1}{4}$
Design or electric traction		x

The 2½ hour sessions in the senior course include a lecture and a period of 1½ hours devoted to practical exercises. Hours for design or electric traction in the fifth year of the advanced course are not assigned, but are subject to arrangement. A sixth year's work is offered and includes two sessions of 2½ hours devoted to lectures on advanced topics and individual problems of research.

WORKSHOP PRODUCTION COURSE (Wolverhampton Technical College)

The first three years of the course are divided into four parallel sections for (1) machinists, fitters and toolmakers, (2) foundry workers, (3) sheet metal workers and (4) motor car body builders, respectively. The program for each consists of three items, each occupying one evening session of 2 or 2½ hours per week; one is a course in workshop processes with lectures and practice, the second a shop drawing course with lectures and practice, and the third a course in mathematics, mechanics and selected elements of other sciences. The fourth year of the course is a common advanced section in advanced shop technology, jig and fixture design and an option between (*a*) book-keeping and works records, (*b*) economics of engineering, (*c*) English, and (*d*) steel and reinforced concrete construction. This is the new course which has attracted wide attention.

Course in Metallurgical Engineering (Wolverhampton)

Senior Course

	Hours per Week		
	First Year	Second Year	Third Year
Mathematics	2	2	
Physics	2½	2½	
Inorganic chemistry, with laboratory	2½		
General metallurgy		1	
Engineering workshops		1½	
Engineering science			2¼
Metallurgical laboratory			2½
Foundry processes and drawing			1½
Iron, steel and metallography *or* Fuels and non-ferrous metals			1

Advanced Course

	Fourth Year	Fifth Year
Workshop sketching and drawing	2	
Metallurgical laboratory	2½	
Engineering laboratory	1½	
Fuels and non-ferrous metals *or* Iron, steel and metallography	1	
Metallurgy, with laboratory		2½
Metallurgical laboratory *		2½
Electrical engineering		2¼

* or on occasion Testing of Materials.

Evening Course in Textile Manufacture (Royal Technical College, Glasgow)

The first two years of the course, comprising elementary mathematics and drawing, is taken in one of the local affiliated schools. The third year mathematics may be taken in an affiliated school; in addition a course of Physics covering 2½ hours per week is taken in the College. The four final years are taken entirely in the College and prepare for the examinations for the Certificate in Technology of the City and Guilds Institute:

	Hours per Week			
	Fourth Year	Fifth Year	Sixth Year	Seventh Year
Weaving, lectures	2	2	2	2
Weaving, practical	2	2	2	2
Mechanics and laboratory	2½			
Engineering drawing		2½		
or				
School of Art course		2		
Motive power engineering			2	
or				
School of Art course			2	
Applied design				2

COURSE IN GAS ENGINEERING FOR THE NATIONAL CERTIFICATES

(Royal Technical College, Glasgow)

SENIOR COURSE

	Hours per Week		
	First Year	Second Year	Third Year
Mathematics	2	2	
Physics	2		
Engineering drawing	2½		
Inorganic chemistry		6	
Electricity and magnetism			2¾
Mechanics and laboratory			2½
Gas Manufacture			1
Gas supply			1

ADVANCED COURSE

	Fourth Year	Fifth Year
Motive power engineering	2	
Mechanics	2½	
Building construction	2½	
Design of structures		3
Fuels		3
Gas manufacture		1
Gas supply		1

COURSE IN STRUCTURAL ENGINEERING (London C. C. School, Brixton)

	Hours per Week			
	First Year	Second Year	Third Year	Fourth Year
Mathematics	2	2		
Building science	2			
Building construction	2	2		
or				
Structural drawing	2	2		
Mechanics and theory of structures		2		
Theory of structures and strength of materials			2	
Reinforced concrete			2	
Land surveying			2	
Field work in surveying			2	
Structural design				2
At least two options:				
Building construction II				2
Building construction III				2
Land surveying I				2
Land surveying II				2
Field work in surveying				2

The work in mathematics extends into elementary calculus; building science includes selected elements of physics and chemistry; building construction covers work with brick, iron, steel, timber, masonry and concrete, also partitions, roofs, floors, plumbing, etc. The course prepares for examinations held by professional institutions.

PART-TIME DAY COURSE IN MECHANICAL ENGINEERING FOR THE NATIONAL CERTIFICATES (Woolwich Polytechnic)

This course is intended primarily for engineering apprentices, whose employers agree to release them three half days per week for school attendance:

Subject	Hours per Week			
	First Year	Second Year	Third Year	Fourth Year
Heat, sound, optics	3			
Mathematics	4	3	3	4
Theoretical mechanics	2			
English	1	1		
Mechanical drawing		2	2	
Applied mechanics		2		
Chemistry and metallurgy		2		
Electricity and magnetism			2	
Applied mechanics and heat engines			3	
Electrical engineering				2
Strength of materials and heat engines				4

The examination for the ordinary national certificate in mechanical engineering is given at the end of the third year, and the fifth year's work for the higher certificate may be taken in the evening or in special day classes.

Part-Time Day Courses.—The value of the type of evening technical instruction illustrated above, covering the entire range of industry and given on a nation-wide basis, is incalculably great. Britain is easily first in the world in training of this character. A century of experience has revealed certain limitations very clearly. There is now a widespread movement, backed by the Board of Education, to increase the number of part-time day classes with attendance made compulsory by employers. Evening class work is essentially voluntary; it must be made popular to draw and hold attendance; it reaches the ambitious rather than the rank and file and trains men to rise above skill rather than to exercise it; and it places on the employer only an indirect responsibility for its support and direction. It is uneconomical to provide expensive laboratory facilities for evening use alone and difficult to maintain an efficient teaching staff solely for this service. Students and part-time teachers who come after a full day's work can not be at their best. Long experience has shown that it is not practicable to expect attendance for more than three evenings and more than a total of seven to eight hours per week; the annual session covers from twenty-five to thirty weeks and the total annual attendance per man averages about 150 hours. Under these conditions the pace of advance is necessarily slow and the program confined within narrow boundaries. With three half days of attendance per week, required by employers, or what is more common—two half days and an evening of voluntary attendance in addition—a gain of 50 per cent or more is realized, making it possible to broaden the work considerably and to do it under far more favorable conditions. For an example, the Woolwich course on page 934 may be compared with the Halifax course on page 928.*

Woolwich had 159 such part-time day students in 1927–28; Coventry, an important automotive center, had 390; and the total for England and Wales amounted to 4,314, which considerably exceeded the total number of students of applied science in all the British universities. One leading electrical manufacturing company has deliberately reduced its intake of university graduates and has gradually increased its recruitment of engineering apprentices from the better secondary schools; this group is sent to one of the strongest technical colleges for a part-time day course which leads to the Higher National Certificate; and the most promising are selected, on the basis of their showing both in school and industry, for scholarships which enable them to complete the full university course.

Fees.—With the definite aim of making higher technical education as widely available as possible, the scale of fees charged for part-time and evening courses is very nominal in comparison with the charges for full-time day courses. The London scale for organized evening courses such as the illustrations cited is £1/10 per year's session for residents of the county. Woolwich charges £1 for a full year's session of the part-time day courses. Wolverhampton charges £10/10/0 per year for its full-time day courses, £1/10/0 for its part-time day courses and £1 for its grouped evening courses. Halifax makes a charge of £15 per year for full-time courses and 13½ shillings for a year's session of a grouped evening course. Glasgow charges by the subject in evening courses and the total fees for a course of three evenings per week range from £3 to £4 per year.

---

* See Report of Investigation of Engineering Education, Vol. I.

Institutions Combining University and Intensive Technical Instruction.—As pointed out before, five important provincial institutions combine the two functions and certain London polytechnics are virtually outposts of the University of London insofar as their full-time day and part of their evening classes are concerned. A considerable number of other institutions offer day instruction of university standard and enable students to qualify for the London external degrees. Success in maintaining both university types and more intensive and practical types of technical instruction in the same institution is due to the fact that each form has attained a strong and stable development independently and that each is held true to its function by external controls. In the mixed institutions the day colleges are invariably smaller in enrollment. It is the almost universal testimony in England that when the situation is dominated by a group of professorial teachers there is a steady drift toward university types and methods, in consequence different teachers are sometimes assigned to full-time and evening classes; the Scottish technical colleges, on the other hand, attach great value to the fact that the same teachers handle day and evening classes and must adapt their teaching to the two types of men. In general, the influence of the national and local educational authorities operates strongly to hold the local institutions true to their special function. In this they are ably seconded by the professional institutions of engineers, chemists and naval architects, and by the national associations representing the technical institutions, their principals and their teachers.

Teachers and Teaching.—Teachers with the actual or virtual rank of university professors constitute a fairly distinct group and have the status, qualifications, salaries, and independence which that position betokens. The general body of teachers in technical institutions, however, have a status practically identical with that of teachers in the nationally aided secondary schools. Their salaries and rates of advancement, conditions of tenure, and retirement privileges are fixed by a national award, known as the Burnham scale, and their duties are regulated by fairly definite schedules. The salaries for fairly responsible posts are somewhat higher, as a rule, than those of university lecturers. Individual treatment, however, is accorded to principals and to heads of departments in the larger institutions which approximates to professorial standards. The actual title of ''professor,'' however, is reserved to men holding university chairs. In general the professorial group are the more scholarly men and the teachers of other types the more actively in touch with industrial practice. Freedom to engage in independent practical work is not assumed, however, and the consent of the authorities must usually be obtained in advance.

The Association of Teachers in Technical Institutions represents the group in negotiations with the national authorities on questions of salary and status and has had a constructive influence on national policy affecting the support and development of technical education. As a direct result of a recent inquiry by the Association and of its representations to the Board of Education, the latter body has lately undertaken two important investigations dealing with the relation of technical education to other forms of education and to industry and commerce.

The usual period of duty for teachers is ten half days per week, counting each evening session as a half day. As a rule, nearly half of the load falls in the evening. The actual teaching load averages about twenty hours per week. Except in the full-time day courses, the home-work expected of students is quite limited in amount—about half the total hours of attendance—and consists largely of problems and practical exercises. The class instruction is necessarily very direct; lecture methods prevail, but the classes are of moderate size and there is enough questioning and discussion to insure that the subject matter has been understood. The teacher must of necessity be a good expositor, with a keen sense of relative values, skilled in condensation and in rapid review. Class, laboratory and drafting room are closely tied together; as a rule each evening's session is devoted to a single subject, combining a lecture and a period of directly related practical exercises. Learning and performance are thus immediately tied together, with a maximum economy of time and effort.

The Summer School for Teachers.—Many of the teachers in local institutions are first recruited through part-time teaching and are themselves products of evening and part-time training enriched by practical experience. To aid in broadening their educational outlook and to give them the aid of intensive coaching on teaching materials and methods, the national Boards of Education have established summer schools which meet annually for a period of three weeks. The session in England is divided equally between the Universities of Birmingham and of Oxford. Special stress is laid at the former on laboratory procedures, for which unusual facilities are available, and at the latter on class-room teaching and broader inspirational matters. The schools are restricted in enrollment; the privilege of attending is often given in recognition of special merit, with expenses paid by the local and national authorities. The inspectors of the Board of Education direct the school; the tutors are the most distinguished university professors of engineering; and the lecturers, as a rule, are men of special eminence in public, industrial and educational life. While the aims of the summer school established in the United States by the Society for the Promotion of Engineering Education are somewhat different, the inspiration and the original model for the undertaking must be credited to the schools at Birmingham and Oxford.

General Observations.—While British technical education still shows its trial-and-error origins, the developments of the past forty years have been orderly and consistent, indicating that harmonious guiding forces and ideals are at work. The course of legislation in the closing years of the last century was largely guided by a voluntary Association for the Promotion of Technical Education, founded in 1887 and later expanded to include secondary education, which disbanded after its aims had been embodied in the Technical Education Acts of 1889 to 1900. More recently the three associations of technical institutions, principal and teachers, respectively, have been an active force from within, and on the whole a distinctly harmonious one. The English and Scottish boards of education have had a cumulative influence through the devoted work of their inspectors, their advisory services to local institutions, their special studies of educational methods, their reports on training for the major divisions of industry, their surveys of technical education in certain areas, their summer schools for technical teachers, their initiative in promoting part-time day courses for apprentices, and their leadership in establishing the National Diplomas and Certificates—a fine example of central aid cooperating with local direction without bureaucratic interference. Technical education in the universities has been guided by a common tradition rather than by any form of association or bureaucracy. The influence of the engineering profession is discussed in later paragraphs.

It is almost amazing to an American observer, accustomed to our promotional methods and rivalries, that there has been so little competition or friction between the two arms of the educational system, also that there is so little interest in purely local innovations. British belief in common experience as a sure guide is nowhere seen to better advantage. Nowhere does one meet the self-assertive ''educationism'' now so common in America. Schools are not conceived as a mere filling-in experience for otherwise unoccupied years, nor is ingenuity strained to provide new incentives for learning. Nothing seems to minimize pedagogy like a frank assumption that the student wants to learn what the teacher wants to teach. The motivation growing out of concurrent industrial experience is a great advantage. It is striking to observe how little full-time technical education the world's most highly industrial nation can survive and prosper on, provided that little is high-grade and part-time education is universally accessible. One finds himself compelled to question whether the American slogan of ''universities for everybody'' is either socially or economically sound.

The distinctive excellences of British technical education stand forth clearly, with significant lessons for our own which need no pointing out: (1) the freeing of the universities from the burdens of quantity production, social assimilation and service teaching in order to serve the intellectual needs of society with singleness of purpose; (2) the abundance and excellence of the provision for these other and equally worthy ends through institutions highly responsive to individual and local needs; (3) effective provision for education in the technology of specific industries as well as in engineering; (4) concentration on fundamentals, integration of teaching and thoroughness of standards in all grades of schools and programs; (5) insistence on practical training and systematic provision for it in all branches of industry and public works; (6) the provision of varied educational credentials, under national sanctions, so that the university degree is safeguarded from inflation and other forms of attainment have due recognition; (7) the controlling influence of the engineering profession on educational standards, without undue encroachment on the freedom of school or teacher; (8) the integrating influence of the national governments, without bureaucratic invasion of university autonomy or of local direction for technical institutions; and (9) the ideal of vertical mobility which has kept caste out of the technical callings and has inspired the ambitious to rise through education to the limits of their ability.

The high importance which Britain attaches to technical education in the present critical period of economic readjustment is revealed in the report of the Balfour Committee, appointed by the Cabinet to inquire into the conditions and prospects of British industry and commerce, on ''Factors in Industrial and Commercial Efficiency.'' Here technical education is given equal ranking with the industrial structure, standardization, scientific research, industrial art, economic measures by the State, and the scale of profits, taxes and transportation charges. A brighter day will dawn for American technical education when leaders of industry and State give it equal recognition.

D. THE HIGHER INDUSTRIAL SCHOOLS OF GERMANY

Levels of Technical Education.—Higher technical education in Germany stands on three clearly defined levels, viz., (1) the technical universities, (2) the higher industrial schools and (3) the middle industrial school. The more elementary forms are included in the continuation schools and trade schools. The universities may be approached only through the complete nine-year program of the secondary schools, terminating with the maturity certificate; they devote themselves exclusively to the more advanced forms of teaching and research, and send their graduates forth as fully accredited members of the technical professions. The higher industrial

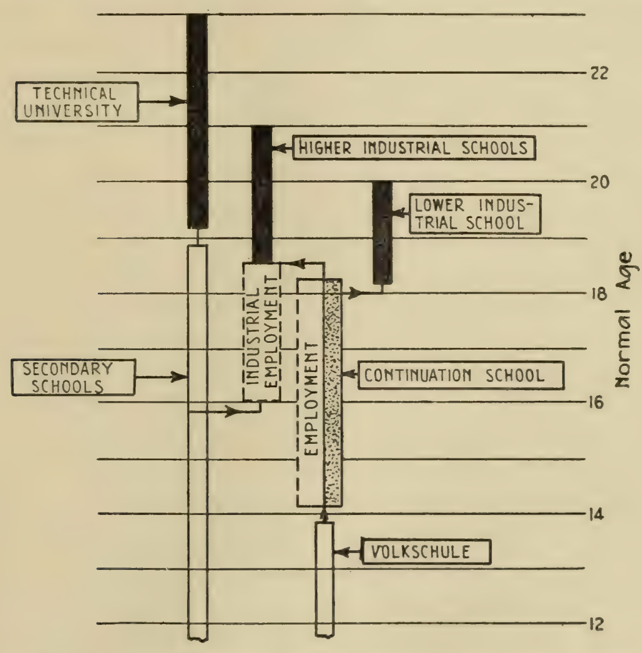

TECHNICAL UNIVERSITY
HIGHER INDUSTRIAL SCHOOLS
LOWER INDUSTRIAL SCHOOL
INDUSTRIAL EMPLOYMENT
EMPLOYMENT
SECONDARY SCHOOLS
CONTINUATION SCHOOL
VOLKSCHULE
22
20
18
16
14
12
Normal Age

FIG. 30. Technical schools in the German educational system.

schools are approached normally through a six-year program of secondary studies followed by two years or more of carefully selected industrial experience or, as an alternative, four years of experience and continuation study following the *volkschule.* Their graduates are prepared for the higher practical pursuits of industry, construction and engineering, and they may qualify for full professional recognition after five years. The middle industrial schools are approached through four years of continuation education and experience following the *volkschulen* and train the intermediate technicians and supervisors of industry. These three levels are characteristic of all Central Europe and Scandinavia.

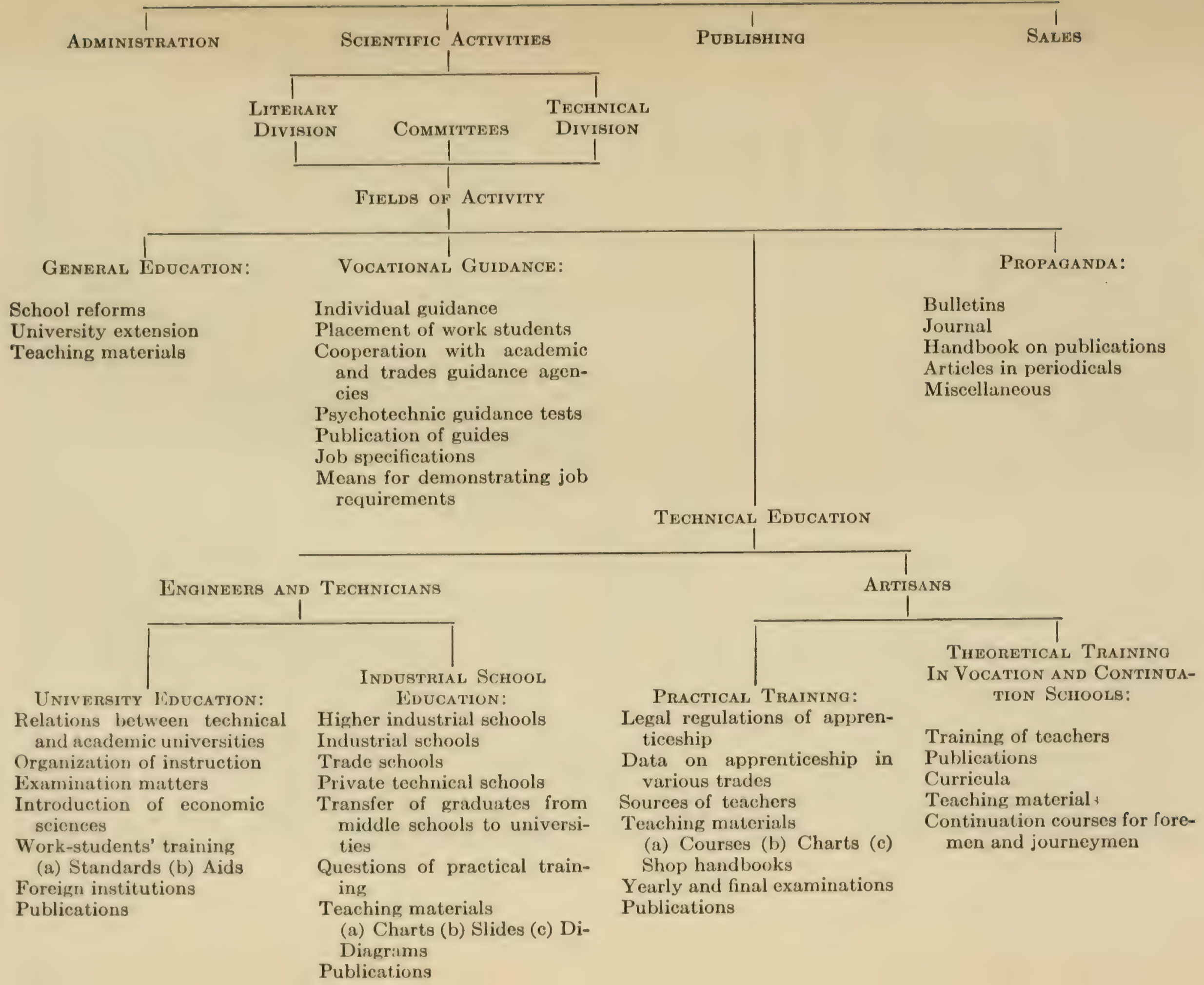
Elementary Schools.—Families are free in theory to choose either an intellectual or a practical education for their children, but economic necessity commonly dictates a choice in keeping with the status of the family. As there is little or no place in the social order for persons with no specific training, a choice must be made which will lead in a pre-determined time to a vocation and ultimately to self-dependence. Secondary education does not in itself lead to any vocation; it is strictly a form of intellectual preparation for higher study. Practically, the only choice lies between the *volkschule* with its fixed terminal point at 14 and the secondary school followed by some form of higher education ending at 21 or 23. Class distinctions, however, have been effectively wiped out of elementary education, and the *vorschule* now serves all groups up to the age of 10, when the paths divide.

Continuation Schools.—The *volkschule* provides a fairly utilitarian education ending at 14, when the pupil enters employment as a *lehrling* and continues his education one day each week for three or four years in a compulsory *fortbildungschule* or continuation school, one of the most distinctive features of the German educational system. The larger cities maintain separate schools for related groups of occupations. In Hamburg, for example, there is an admirable modern school for all groups concerned with the production and supply of food products where grocer's boys, baker's helpers, apprentice waiters, etc., follow distinct courses built up around their specific needs and interests. Industrial concerns are encouraged to maintain internal works schools for apprentices, subject to public regulation. Excellent examples may be seen at the Blohm and Voss shipyards in Hamburg, the German General Electric Company's works at Berlin, and at Sulzer Brothers in Winterthur, Switzerland. The technical instruction, which bears directly on the special industry, is supplemented by courses in German and civics, and by many admirable recreational and welfare features. The more promising boys in technical pursuits are prepared for entrance at 18 into the middle industrial schools, which give a two-year full-time program. Others who aim still higher, may qualify by supplementary evening classes for the entrance examinations of the higher industrial schools.

Types of Secondary Schools.—The democratic influences of recent years have widened the paths of access to secondary education without changing its essential quality. The tuition charges are scaled to the means of the family and in cases of need are remitted entirely. The system is still essentially selective; education is still an exacting intellectual process and not a sentimental privilege. Three types of secondary schools with nine-year programs have the highest standing and privileges. The *gymnasium* emphasizes Latin and Greek; the *realgymnasium,* Latin in combination with modern languages and to a less degree science; and the *oberrealschule,* science, mathematics and modern languages. There are also six-year secondary schools which carry the boy only to the *obersecunda* grade. Formerly this grade had a very special significance, for boys who passed the examination were classed as *einjähriger,* that is, they were required to render only a year of military service and might do so as "volunteers" in a regiment of their choice. Today the *obersecunda reife* is of value chiefly in qualifying the boy for admission, after two years or more of carefully chosen industrial experience, to one of the higher industrial schools. To the older types of secondary schools, a fourth, dealing mainly with German culture and modern languages, is now being added.

The Higher and Middle Industrial Schools.—Schools of these types, for which we have few counterparts in America, are commonly known throughout central Europe by the name *technikum.* No collective statistics are available, but the total number in Germany is well above one hundred, with a total enrollment between 25,000 and 30,000. As a rule these schools are semi-monotechnic in type. The *maschinenbauschulen* prepare for the mechanical and electrical industries; the *baugewerkschulen* for architecture and civil construction; the *bergschulen* for the mining industry; and a rather varied group of *gewerbeschulen* for such specific industries as textiles. leather work, paper manufacture and the like. The great majority and all of the strongest of these schools are state or municipal institutions. There are some private schools, but they are not in high favor with the public authorities and the professions, and are having a hard struggle for survival. The state schools, as a rule, are under the direction of the Ministry of Commerce and Industry. Complete separation of control tends to lessen any potential rivalries between the industrial schools and the *hochschulen,* and apparently has led to some emulation in generosity of support.

The German Committee for Technical Education.—On the initiative of the *Verein Deutscher Ingenieure* there was established in 1908 a joint committee representing all the professional and industrial interests in technical education from the training of workmen to that of directing engineers. Its membership now includes forty societies and associations as well as a large number of industrial firms. Membership is gained by invitation, and funds for the Committee's work are derived from annual subscriptions and from sales of publications and teaching materials. The name of the Committee (*Deutscher Ausschus für Technische Schulwesen*) has been colloquially abbreviated to *Datsch.* The range of its activities is indicated by the accompanying function chart. The *Datsch* is administered by a general committee of six, and



- ADMINISTRATION
- SCIENTIFIC ACTIVITIES
  - LITERARY DIVISION
  - COMMITTEES
  - TECHNICAL DIVISION
    - FIELDS OF ACTIVITY
      - GENERAL EDUCATION:
        - School reforms
        - University extension
        - Teaching materials
      - VOCATIONAL GUIDANCE:
        - Individual guidance
        - Placement of work students
        - Cooperation with academic and trades guidance agencies
        - Psychotechnic guidance tests
        - Publication of guides
        - Job specifications
        - Means for demonstrating job requirements
      - TECHNICAL EDUCATION
        - ENGINEERS AND TECHNICIANS
          - UNIVERSITY EDUCATION:
            - Relations between technical and academic universities
            - Organization of instruction
            - Examination matters
            - Introduction of economic sciences
            - Work-students' training (a) Standards (b) Aids
            - Foreign institutions
            - Publications
          - INDUSTRIAL SCHOOL EDUCATION:
            - Higher industrial schools
            - Industrial schools
            - Trade schools
            - Private technical schools
            - Transfer of graduates from middle schools to universities
            - Questions of practical training
            - Teaching materials (a) Charts (b) Slides (c) Di-Diagrams
            - Publications
        - ARTISANS
          - PRACTICAL TRAINING:
            - Legal regulations of apprenticeship
            - Data on apprenticeship in various trades
            - Sources of teachers
            - Teaching materials (a) Courses (b) Charts (c) Shop handbooks
            - Yearly and final examinations
            - Publications
          - THEORETICAL TRAINING IN VOCATION AND CONTINUATION SCHOOLS:
            - Training of teachers
            - Publications
            - Curricula
            - Teaching materials
            - Continuation courses for foremen and journeymen
      - PROPAGANDA:
        - Bulletins
        - Journal
        - Handbook on publications
        - Articles in periodicals
        - Miscellaneous
- PUBLISHING
- SALES

by two managing directors. It is undoubtedly one of the most influential non-governmental coordinating forces in German education. Its work in vocational guidance and in the publication of teaching charts which exhibit technical standards, right and wrong construction practices, general economic facts and relationships, etc., has been especially noteworthy. The principal journal on technical education in German, *Technische Erziehung,* comes from its editorial offices. As the work of the *Datsch* benefits all industries, large and small, it appeals for subscriptions on the scale of from 3 to 10 pfennigs per year per employee.

Types of Industrial Schools.—As the industrial system holds little or no place for the untrained man the importance of a graded system of technical education which covers the entire range from the artisan to the research scientist is universally recognized. Limited places and scanty means forbid any sentimentalism about training every boy to go to the top. Everyone accepts the principle of selection in technical education, based on a combination of personal aptitude, previous education and the test of actual experience. Unbroken schooling is little favored as a mode of preparation, except for research scientists. The higher and middle industrial schools cater to young men who have spent from two to four years in practice and through this trial have shaped their purposes to quite definite ends. This break, as a rule, makes them less bookminded and more disposed to the practical than the highly intellectual pursuits. Furthermore, the strong scientific emphasis in the training of the technical universities needs a counterpoise of more practical character. German industry would probably find it hard to manage without the more practically trained *techniker* as an intermediary between the *diplom-ingenieur* and the working forces. There are vast numbers of small industries in all central Europe into which the highly professional *diplom-ingenieur* scarcely fits at all and which need a more adaptable type of technical direction.

The technical universities and the intermediate schools organize their work on quite different lines. The entire scheme of university teaching is professional. Each professor is king of his castle and teaches his subject with a large measure of independence. Students come and go as they please, piecing together the units of instruction and performance needed to pass their several qualifying professional examinations. The intermediate technical schools, in contrast, organize their teaching on industrial lines—mechanical, electrical, structural, mining, metallurgical, shipbuilding, textiles, and the like; their regime is but little less disciplinary than that of industry itself; and their teaching is built up in closely coordinated programs.

The most numerous types are the *maschinenbauschulen* devoted to the electrical and mechanical industries, the *baugewerkschulen* for architecture and the structural industries, and the *bergschulen* for the mining industries. In general there are two classes of schools and programs under each type, the so-called ''higher'' type which requires a superior academic preparation and leans strongly toward the technical side, and a ''middle'' type which leans toward the operating and supervisory side. These distinctions, however, are less marked in the *baugewerkschulen*. The schools for other industries are of a more composite character.

The *maschinenbauschulen* are the most numerous of the several types. Germany has twenty of the ''higher'' type and eighteen of the ''middle'' type under state and municipal auspices, as well as ten of the former and six of the latter under private auspices, making fifty-four in all. There are forty-nine *baugewerkschulen* giving programs of the higher type in Germany, many of which also give courses of the middle rank. The *bergschulen* are numerous in the mineral basins, Prussia alone having thirteen, of which four give courses of the higher type. Sweden has five higher schools and six middle schools, as well as two mining schools of the latter rank, all under state control. Switzerland has seven *technika* of diverse types, mostly under cantonal auspices.

The Maschinenbauschulen.—The higher and middle types of schools are seldom combined in a single institution. The two teach many similar subjects, but on different technical levels, and the middle schools in recent years have taken an increasing orientation toward management rather than design. The higher schools are recognized by the *Datsch* as engineering schools and their graduates are accepted by the *Verein Deutscher Ingenieure* after five years of additional experience. Those who wish to pursue higher professional studies are eligible to attend the technical universities as auditors, but may not take the examination for the professional diploma. The certificate of the *obersecunda* examination is normally required for admission, with two years of subsequent experience along rather closely specified lines, but others with four years of experience may also be admitted on passing entrance examinations in German, mathematics, and science equal to the *obersecunda* standard. About three-quarters of those admitted are of the former type. The normal age of entrance lies between eighteen and nineteen. The middle schools require certificates from the *volkschule* and the continuation school and four years of experience, the greater part of it in the industry for which the applicant wishes to prepare. The entering students range from eighteen to twenty-one.

The *Datsch* has described the functions of the higher and middle schools for the machine industries as follows:

> "The Higher Industrial School (*Höhere Maschinenbauschule*) should give its students a training which will fit them to be successful mechanical technicians in designing offices, in the direction of machine building shops and in similar technical works,"
>
> "The Middle Industrial School (*Maschinenbauschule*) should give its students a vocational training which will prepare them as future supervisors of workshops, proprietors of small concerns or as technical assistants in designing offices and in management."

Characteristics of the Higher Machine Schools.—The higher schools usually have semi-distinct divisions for mechanical and electrical engineering and some of the larger schools add one or more divisions in some such kindred fields as fine mechanisms, naval architecture, marine engineering or metallurgy. The courses of study cover five semesters of twenty weeks each, with a weekly attendance ranging from 40 to 44 hours per week. The laboratories, as a rule, are excellent, carefully planned for teaching rather than research, and admit of semi-individual work on the part of all students. One is impressed by the definitely technical quality of the teaching of mathematics, physics and chemistry. The special rooms for the two latter subjects serve as combined classrooms and laboratories and the experimental work deals almost wholly with technical mechanisms, instruments, materials, magnitudes and situations. On every hand there is an abundance of material for visual education—models, machine parts, cut-out machines, specimens of defective workmanship and design, charts, and diagrams—an art in which Germans seem to surpass all other peoples. Most of the classrooms are fitted with individual drawing tables. No separate drafting rooms are provided; in many cases each section of students has its permanent room, each student his permanent desk, and the teachers of all but the laboratory subjects come and go according to the time schedule. Under this plan there are no large lecture courses. All instruction is given in sections ranging from 15 to 40, with an average of perhaps 24. The teaching is *seminaristisch,* that is it is a combination of exposition by the master and discussion between the master and the student. Practically no instruction is given from textbooks; direct methods prevail and the teacher is the primary source; but manuals of reference for subsequent use are rather widely employed.

The instruction, as a rule is not highly mathematical. The work in mathematics proper, which extends somewhat into calculus, is geometrical in its emphasis and concrete in its teaching material. The students are habituated from the beginning to graphic language and analysis and quickly acquire a skill in presentation which is admirable. Comparatively little time, however, is spent in making carefully inked plates; trust German sense of economy for that! No attempt is made to teach the practical operations of mechanical and electrical construction—these must be learned in practice. The rather excellent collections of machine tools are used as laboratories, pure and simple, the machines being fitted with indicating and recording instruments which enable the students to study their performance in a critical manner.

As the programs call for forty hours or more per week, the work is largely done on the school premises under supervision. The outside work consists chiefly in the transcription of notes, the working of practical exercises and projects, and the preparation of laboratory reports. The latter, as a rule, are fairly simple memoranda rather than extended memoirs. There is none of the *lern-freiheit* of the universities. Students are required to attend all their assigned exercises and perform their work punctually. Grades and promotions are based on daily performance and on term examinations. The standards are comparatively strict and there is a much larger degree of elimination in course than in the universities. As a rule the number of graduates ranges from 45 to 60 per cent of those admitted. A jury appointed by the Ministry, but including representatives of the school staff, gives a comprehensive final examination, partly written and partly based on an inspection of the student's portfolio of drawings, reports, and other practical exercises. Success in this examination makes the graduate eligible for certain civil service appointments, but no professional title is conferred.

The Middle Mechanical Schools.—The facilities and methods of the middle schools resemble those of the higher schools, except for the difference in the technical level and the orientation of the instruction. More attention, as a rule, is given to what is called mechanical technology, or the practical processes of mechanical industry. For example, the *maschinenbauschule* at Essen has comparatively modest laboratories of heat engines, electrical machinery, hydraulic machinery, etc., but has a more extended machine tool equipment than the higher schools and an excellent laboratory of autogenous welding. The mathematical instruction is definitely practical in character; there is an extended review of arithmetic, with especial reference to the calulation of interest and costs, to the use of tables, to interpolation, and to the use of computing machines. Algebra, plane geometry and trigonometry are covered selectively for their mechanical and management applications. The work in the third semester has largely to do with graphic representation and the mathematical uses of handbooks.

Examples of Curricula of Maschinenbauschulen.—*Typical* programs have been selected from the mechanical and elec-

CURRICULA OF HÖHERE MASCHINENBAUSCHULE, HAMBURG
Mechanical Section

	Semester				
	I	II	III	IV	V
	Hours per Week				
Mathematics	10	6	4		
Mechanics	10	10	6		
Chemistry	4				
Projection drawing	6				
Industrial hygiene	2				
Machine drawing and design	10	12	4		
Mechanical technology	2	4	4	4	2
Acoustics and optics		2			
Thermodynamics		2	4		
Laboratory of technical physics			4		
Electrotechnics		4	4	2	
Hoisting and conveying machinery		4	6		
Boilers			4	4	
Steam engines			4	6	
Internal-combustion engines				4	
Steam turbines				4	
Electrotechnical laboratory				2	4
Building construction				2	4
Pumps and water turbines				4	2
Political and social economy				4	6
General options				2	2
Special branches of machine construction					4
Chemical laboratory					2
Autogenous metalworking					2
Design projects					12
Mechanical laboratory				6	6
Total	44	44	44	44	46

Electrical Section

	Semester				
	I	II	III	IV	V
	Hours per Week				
Mathematics	10	6	4		
Mechanics	10	8	4		
Chemistry	4				
Projection drawing	6				
Industrial hygiene	2				
Machine drawing and design	10	12			
Electrical technology	2	4	4	4	2
Acoustics and optics		2			
Electrical science		8	6		
Thermodynamics		2			
Electrical measurements		2	4		
Laboratory of technical physics			2		
Building construction			4		
Power machinery			6	6	
Electrical machinery			8	10	12
Electrical communications			2	4	
Social and political economy				4	6
General options				2	2
Electrical installations and layouts				8	4
Laboratory of electrical machinery				4	8
Laboratory of electrical communications				2	4
Special applications of electricity					4
Mechanical laboratory					4
Totals	44	44	44	44	46

trical sections of the higher mechanical school at Hamburg and from the section for fine mechanism at Esslingen. The example of a middle school program is from Essen. There are many local variations. The State Ministries, as a rule, prescribe or approve the course schemes. No effort has been made to bring them all into conformity, but the German tendency to adhere to common types and traditions holds the programs of common rank within fairly narrow ranges of diversity.

Curriculum of Höhere Maschinenbauschule, Esslingen

Section for Fine Mechanisms

	Semester				
	I	II	III	IV	V
	Hours per Week				
Economics, Civics	2	2			
Mathematics	8	6	4		
Descriptive Geometry	6				
Physics	8	2			
Chemistry	4				
Technical Mechanics	4	4	6		
Strength of Materials	4	4			
Machine Drawing	6				
Mechanism and Machine Elements		8	4		
Metallurgy		2			
Pattern Making and Foundry		2			
Surveying		2			
Elements of Electrotechnics		6	6		
Physical Laboratory		2			
Chemical Laboratory		2			
Thermodynamics			2		
Hydraulics			2		
Mechanical Materials			4	2	
Structures			2		
Technical Measurements			6		
Electrical Machines			2		
Materials Laboratory			2		
Electrotechnical Laboratory			2		
Industrial Management				4	2
Tools and Instruments				8	
Machine Tools				4	8
Design of Elements				12	
Design of Instruments and Apparatus					16
Manufacture				4	8
Heavy Current Electrotechnics				2	4
Electrical Communications				4	2
Acoustics and Optics				4	
Theory of Machines					4
Optional Study	2	2	2		
Total	44	44	44	44	44

CURRICULUM OF MIDDLE MASCHINENBAUSCHULE, ESSEN

	Semester			
	I	II	III	IV
	Hours per Week			
German, Civics, Economics	4			
Mathematics	15	5	2	
Physics	6			
Chemistry	2	2		
Drawing	11			
Mechanics		5	4	2
Mechanism and Machine Elements		16	4	6
Power Machinery			9	9
Electrotechnics		4	4	4
Industrial Plants			2	4
Industrial Technology	2	6	7	6
Hoisting and Conveying Machinery			2	4
Exercises in the Laboratories		2	6	6
Total	42	42	43	43

Purpose and Character of the Baugewerkschulen.—These schools bear the same relation to the construction industry as the *maschinenbauschulen* to the mechanical and electrical industries. In fact, it is said that fully nine-tenths of the buildings erected in Germany are designed and executed by men trained in the *baugewerkschulen.* These schools have virtually created the domestic architecture of Germany, so distinctive and homogeneous yet free from monotony, and are the most active agents in its further development. The purposes of the schools, as set forth in the official circular of the Prussian Ministry of Commerce and Industry are:

> "(*a*) to give managers of construction work who wish to perfect themselves in architecture or technical construction, especially masons, carpenters and stone workers, the opportunity to acquire theoretical knowledge and ability in drawing and design which are needed for the independent practice of their callings;
>
> "(*b*) to train architectural and technical assistants for offices and field works (*bautechniker* and *bauführer*); and
>
> "(c) to prepare officials for the technical services of the federal, state and municipal government."

Whereas the technical universities teach architecture and structural engineering on a comparatively ambitious scale, the *baugewerkschulen* put their emphasis on the design and construction of the utilitarian structures of everyday life, farmsteads, dwellings, apartments, schools, industrial buildings, single-span bridges, small water powers and the like. Modern forms are everywhere emphasized, while monumental construction and gothic and classical forms and ornament receive only incidental treatment. Much attention is paid to the economics of building, both in distinct courses given to the subject and in the more technical branches. A number of the schools have short courses for surveyors.

The schools are organized and their teaching conducted in a manner much like the higher machine schools. For admission to the higher courses the *obersecunda* certificate is required or an equivalent examination and two years or more of building experience divided between the field and the office. The laboratories are less extensive than in the mechanical schools, but the collections of structural parts, samples of materials, pictures, drawings and casts are often elaborate. The student is taught to think from the outset in graphic terms and forms and quickly acquires a rapidity and excellence of presentation which amazes an American visitor. Instruction is given in small classes in rooms fitted with drawing tables, each student having his own permanent post. The admissions are limited and to a considerable degree selective.

There are forty-nine schools of this type in Germany, twenty-six of them in the State of Prussia. The enrollment ranges from 200 to 600 per school. The principal programs are five semesters in length, the minor programs one year. Each semester normally occupies twenty weeks. Promotion from semester to semester is based on daily work and term examinations. The State gives a final examination, directed by a jury, the principal purpose of which is to determine the eligibility of graduates for civil service appointments. However, no professional title is conferred.

Typical Curricula of Building Schools.—Many of the schools have separate sections for architecture (*hochbau*) and for technical construction (*tiefbau*). Others, like the admirable school at Stuttgart, give only a single major program. Stuttgart, however, has a post-graduate program of one year in hydraulic engineering (*wasserbau*). The following examples of the architectural and technical programs are taken from the official regulations issued by the Prussian Ministry of Commerce and Industry for the twenty-six *baugewerkschulen* under its direction:

Curricula of Prussian Baugewerkschulen

	Semester and Section							
	Common		Hochbau			Tiefbau		
	I	II	III	IV	V	III	IV	V
Conduct of Business	2	2	2			2		
Civics	2	2	2	2	2	2	2	2
Mathematics	9	6	2			3	2	2
Physical Science	2	2	2			2		
Perspective	3			2	2			
Free Hand Drawing	2	2	2	2	2			
Lettering	2	2	2			2		
Architectural Drawing	7	6	6	4	4	5		
Architectural Forms	2	2	2	4	3			
Model Making	2	2	2				4	
Building Construction	7	7	6	9	4	4	2	8
Building Materials		2	2		2	2		2
Mechanics of Structures		3	3	4	5	4	4	5
Surveying			2			2	4	
Plans and Equipment	2	2	5	3	4			
Economics and Management		2	2	4	4	2	4	4
Electives	2	2	2	2	2	2	2	2
Projects				8	10			
Municipal Engineering							4	4
Hydraulic Construction							4	5
Bridges						2	4	3
Steel Frames						2	2	
Foundations						2		
Reinforced Concrete						2	2	3
Earthwork and Railroads						4	4	4
Total	44	44	44	44	44	44	44	44

Five of the Prussian *baugewerkschulen* give a two-semester course in surveying with the following program. The minimum age of admission is 17 and candidates are required to have a good *volkschule* and continuation education.

CURRICULUM IN SURVEYING, PRUSSIAN BAUGEWERKSCHULEN

	Hours per Week	
	I	II
German and Business Practices	2	2
Civics	4	4
Arithmetic	2	
Algebra	4	3
Geometry and Stereotomy	4	3
Trigonometry	3	4
Physical Science	2	2
Lettering	2	
Projection Drawing	1	
Surveying and Levelling	8	12
Plotting	6	8
General Construction	6	4
Aerial Surveys	1	
Total	45	42

The *höhere bauschule* at Stuttgart has a post-graduate curriculum in hydraulic engineering, which occupies two semesters;

POST-GRADUATE CURRICULUM IN HYDRAULIC ENGINEERING, HÖHERE BAUSCHULE, STUTTGART

	Hours per Week	
	I	II
Applied Mathematics	4	
Electrotechnics	2	
Geology	4	
Power Machinery	4	
Practical Geometry and Surveying	6	4
Hydraulics	4	4
Hydraulic Computations	2	
Hydraulic Construction	6	6
Hydraulic Power Development	6	10
Water Supply	2	4
Piping Systems		4
Applications to Agriculture		4
Safety and Industrial Hygiene		2
First Aid		1
Total	40	39

The Bergschulen.—The schools of practical mining are operated on a part-time plan whereby the students continue their work in the industry from four to six half days per week during the school year and work full time during the summer. Two grades of instruction are given: the *steiger* courses are intended for the training of foremen for the underground, above-ground, mechanical and electrical departments respectively; and the *oberklasse* is of a more advanced grade for graduates of the *steiger* courses who wish to qualify as superintendents. Professional mining engineers are trained at the technical universities and higher mining schools.

To be admitted to the *steiger* class the applicant must be not less than 21 years of age and, as a rule, have completed the course in a *bergvorschule* or have the *obersecunda* certificate from a secondary school. The *bergvorschule* is a part-time continuation school for graduates of *volkschulen* employed in the mining industry. The candidates must also have had four years of active mining experience. Candidates for the *oberklasse* must be between 25 and 35 years of age and must have had at least one year of experiene in the official ranks. Furthermore, they must hold a certificate of completion from the *steiger* class with a rank not less than ''good'' or pass an entrance examination.

Examples of Bergschule Curricula.—The following examples are taken from the *Bergschule* at Bochum in the Ruhr, the largest and most prominent of the schools for the coal mining industry:

Curriculum for Mine Foremen, Bochum

	Semester				
	I	II	III	IV	V
	Hours per Week				
Mathematics	4	2	2		
Mechanics	2	2	2	2	
Materials	2				
Drawing	4	4	4	2	
Physics and Chemistry	2	2	2		2
Mining	3	7	3	4	6
Civics and Mining Law	1	1	1		
Surveying and Mapping	2	2	2	2	
Mining Machinery			2	4	4
Electrotechnics				2	2
Management					2
Total	20	20	16	16	16

Note: The classes are held in two divisions; one group spends the morning in the mines, the afternoon in the school; the second, vice versa.

Curriculum for Mine Superintendents (Oberklasse), Bochum

	Hours per Week	
Mining Operations	4	4
Industrial Law and Economics	2	2
Coal Preparation	2	2
Mathematics and Mechanics	2	2
Mining Machinery	4	6
Electrical Machinery	4	4
Mine Surveying and Mapping	4	4
Mineralogy and Stratigraphy	2	
Geology	2	2
Physics and Chemistry	4	4
Drawing	4	4
Total	32	32

Note: Members of the *oberklasse* work two full days per week in the mines.

A Leading Textile School.—Only a single example can be chosen of the many schools which prepare for specific industries. The *Technikum für Textilindustrie* at Reutlingen is maintained by the State of Wurtemburg and is one of the most widely known schools of its class in all Europe. It has close working relations with the technical university at Stuttgart which permit students of the latter in the mechanical division to spend one or more semesters at Reutlingen in order to gain special qualifications in textile engineering. The *Technikum* has in operation a complete textile manufacturing plant, covering all the operations from the preparation of the raw materials to the manufacture of cloth, knit goods and certain lines of sewn and embroidered articles. Divisions and courses are organized as follows:

Spinning Division	1-year Course
Weaving Division	1-year Course
Sewing and Embroidery	1-year Course
Division for Designers	2½-year Course
Chemical Division	2-year Course
Course for Salesmen	½-year Course
Bleaching, Dyeing, Printing and Finishing	Short Elementary Courses for the Mechanical Divisions
Commercial Course	1 Year, 2 Hours per Week

Status of Teachers.—The salaries, titles and schedules of the teachers in the higher and middle industrial schools are virtually the same as those of teachers in the higher types of secondary schools. These appointments are eagerly sought after, as they carry a desirable social position, a fairly comfortable salary, security of tenure and the privileges of a state pension upon retirement. The rosters of the several schools show a higher proportion of doctors of philosophy and of engineering than all but a very few of our engineering colleges. In a few of the states the higher teachers are allowed to use the title of ''professor''; this practice, however, is being discouraged and the title of *studienrat,* or counsellor of studies, is coming into general use.

The work loads are fairly heavy, averaging about 24 hours per week for a teaching year of ten months, with preparation and correction in addition. As a rule there is only a small margin of time for practice, research or scholarly work and the production in these forms is of distinctly creditable amount and quality. A few of the schools have special research institutes, as that for low-head hydraulic motors at Esslingen, but this condition is exceptional. Systematic teaching is stressed and original work left largely to the universities.

As a concrete example of the status of teachers, the terms of appointment at Hamburg are as follows: candidates are expected to hold the diploma of engineer or a higher degree, to have had five years or more of practical experience, and to pass through a probationary appointment before being given a permanent status; their salaries rise by steps to a maximum of 11,000 marks ($2,750) per year, which affords a place in the social scale—though not in the scale of buying power—corresponding approximately to about twice that salary in the United States.

Costs and Fees.—The costs per student per year of the higher machine schools and building schools of the states of Prussia and Hamburg were stated officially to average between 800 and 850 marks, or about half the unit costs of the technical universities. In the same institutions the annual tuition fee is 80 marks, the remainder being made up by the State. These data are typical of the entire public system. The private schools, most of which are entirely dependent upon their fees, are having a difficult time to survive in the face of the generous support given to the State schools.

Appreciation.—In the author's judgment nothing in the entire educational system of Central Europe has more value as an example to America that these admirable schools, with their clear perception of practical aims, their direct methods, their efficient use of time and equipment, and their integration of teaching with industrial experience.

General Observations.—Technical science is pursued with an intensity in Central Europe which is little known in America. What Germany and Switzerland lack in space and natural resources they endeavor to make up by supremacy in the arts of refining and fabrication. In Scandinavia, where economic pressure is less severe, technical science is invoked to maintain general comfort at a high level with limited resources. American interest in engineering has centered in the exploitation of resources and markets assumed to be limitless, with less incentive to high economic utilization than to boldness and originality in the face of natural difficulties. Furthermore, crowded populations are necessarily more closely regimented into professions and vocations, with less freedom for individual initiative.

The social and economic ends of technical education are sensibly different in the two areas. Ours is conceived as an aid to the progress of individuals of varying needs and tastes, and only secondarily as a processs of recruiting well defined callings. Our technical professions have no codes of qualifications which make for definiteness of educational aims and standards. Not so in Germany or elsewhere in Central Europe; there technical education is a definitely organized arm of the body economic, controlled by the brain of the system—the State. Standards are set objectively by State examinations; technical education is graded; each type of diploma carries certain career privileges and limitations; and it is difficult to rise from one caste to another by sheer force of personality. Because their aims are more clearly visualized, their educational system is more logically organized. For both reasons it is more efficient in some respects, and in others attains an efficiency equal to our own at far less cost in paternalism.

The *maschinenbauschulen, baugewerkschulen* and *bergschulen* have few counterparts in America, where we seem unable to think in any other terms than ''college'' and ''trade'' education and commonly take it for granted that formal education should normally be a continuous process from beginning to end. The author feels that these institutions have a more immediate lesson for us than have the technical universities. Until we have created schools of a comparable character for the higher practical pursuits of technical industry, with facilities and enrollments fully equal to our 100 best engineering colleges, it will be difficult or impossible to raise the scientific and professional level of our college instruction much above its present compromise level.

We can have only admiration for the responsible and constructive part taken by the engineering profession in the direction of technical education in Germany. It is remarkable that in an essentially bureaucratic system, the profession has voluntarily built up its influence to a level fairly equal to that of the State and has given it so effective an instrument as the *Datsch.* Technical education has unlimited freedom in the United States, but is left to grope its way and to fend for itself. Herein are potentially its greatest strength and its greatest weakness, for educational progress depends not alone on experiment and innovation, but equally on clearly visualized aims for both the schools and the professional body.

Beyond all doubt, Germany is spending more in proportion to her means on technical education and research than any other of the great economic powers. It would be untrue to the facts to suggest that all is progress and prosperity; there are eddies and backwaters in the stream—antiquated plants, overcrowded amphitheatres and laboratories, lack of facilities for individual work, professors isolated during the war and outdistanced in their specialties, ineffectual teachers—but the main current rolls on with an impression of quiet but irresistible power.

E. OTHER EUROPEAN SYSTEMS

In general the organization of technical education in Latin Europe approximates to French models, in other areas to German. It is of interest to note that both Sweden and Switzerland, perhaps the most democratic of European countries, have developed strongly the regional types of middle and higher industrial schools, as well as excellent technical universities.

Sweden.—*Technical trade schools* (middle schools) are maintained by the State; two for mechanical industries, one for electrical, one for chemical, one for wood products and one for the building industry. In addition there are two private schools (State-aided) for mining and metallurgy. The minimum age of admission is 17 years, the average age from 20 to 22 years. Admission is based on at least two years of trade experience and a certain minimum knowledge of mathematics and other subjects. The courses last two years of 40 weeks each. The total attendance ranges from 300 to 500 and the graduates are prepared to become foremen and assistant superintendents.

Technical gymnasia require for admission the intermediate certificate of a secondary school, usually attained at an age of 16, which represents a fair attainment in mathematics and science, as well as some foreign language. The average age of admission is 18, following a period of practical work. The course covers three years of 38 weeks each and six months must be spent in practical work before leaving. There are five of these schools, all maintained by the state. The school at Malmö has a mechanical bias; at Härnösand the bias is also mechanical with special reference to wood industries; at Orebro provision is made for mechanical, electrical and chemical technology and for commercial subjects; the school at Borås has a textile bias and that at Norrköping a building bias. In addition the Chalmers Institute at Gothenberg has a junior division with a marine and mechanical engineering bias. The total enrollment is between 450 and 500. Graduates find employment in the State railways and technical services, in architects' offices and as technical experts in the machine industries.

Switzerland.—The Federal technical university at Zurich is essentially a higher professional school of engineering, architecture, forestry and chemistry. The several cantons maintain *technicums* which resemble the middle and higher industrial schools of Germany. The trades sections require only a common school education, attained at a minimum age of 14. The technical sections require at least two or three years of secondary education, a minimum age of 15, and in some cases partial completion of an apprenticeship. The technicum at Winterthur, which is probably the most advanced in its standards requires a two-year stage in industry and an examination for entrance. The range of instruction in the technical sections is shown by the following conspectus:

TECHNICAL COURSES IN SEMESTERS, SWISS TECHNICUMS

Course	Brieme	Berthoud	Chaux-de-Fonds	Fribourg	Geneva	Le Loele	Winterthur
Building	6	5		7	6		6
Chemical		5					6
Electrical	6	5		7	6	9	6
Horology			8			9	
Mechanical	6	5	8		6	9	6
Railroads	4						
Posts	4						
Industrial Art				6		9	
Surveying				4			
Commercial							6

Library
N. C. State College

INDEX

A STUDY OF TECHNICAL INSTITUTES

Volume II, Part 2

(Index to Volume I and Part 1 of Volume II concludes Part 1, pages 1303 to 1320)

Aberdeen, England, 217, 223
Admission, 145
  competitive, France, 205
Admiralty, apprentice training, 220
Advisory Committee, ii, v
Ages of students, 146
  of teachers, 152
Agriculture, employment in, 74
Aims for technical institutes, 63
Aix, 24
Alais, 205
Alumni, see Graduates
American Council of Education, 133, 136
American and European educational attitudes, 28, 199, 267–269
Animal husbandry, 74
Apprentices engineering (British), 218–220
Apprentices' library, 30
Architectural courses, 40–45
Armour Institute, Chicago, 37
Arts et Metiers, schools of, 211
Associateships (British), 233
Association of Teachers in Technical Institutions (British), 243
Attendance at institutes, reasons for, 91–95
Automotive engineering, 44

Balfour Committee, report of, 246
Battersea, 223
Baugewerkschulen, 250, 253, 268
  curricula of, 262, 263
  purpose and character of, 260, 261
Belgium, typical schools in, 200
Bell Telephone system, 185
Bergschulen, 74, 250, 253, 264, 268
Bergvorschule, 264
Birmingham, summer schools at, 244
Bliss Electrical School, 39, 137
  ages of students, 146
  drop-outs, 161, 162
  electrical engineering, 40, 176
  fees and costs, 187
  financial outlook, 188, 189
  finishing school, 177
  full time day courses, 40, 138
  graduates, placing of, 189
    views of, 193, 194
    occupations and courses, 115
  objectives of freshmen, 89, 90
  opinions of directors, 194–198
  preparatory education, 145
  student life, 109
    work schedules, 165
  subjects taught, 160
  teachers, recruitment, 153
  teaching loads, 163
    materials, 158
Blohm and Voss shipyards, 249
Board of Education (British), 214, 218, 223
  investigations of, 243
  part-time day classes, 240
  summer school for teachers, 244
Bochum, bergschule, 264–265
Boras, school at, 270
Borough Polytechnic Institute (London), 235
Bourses (France), 203
Bradford-Durfee Textile School, 40, 83
Bradley Polytechnic Institute, 37, 40, 137
British and American experience, 28
British, see Great Britain
  see Board of Education
Brixton, 239
Building construction courses, 40–44, 171
  at Paris, 205
Building Courses, 43–45
Building schools (Germany), 262

(For Index to Vol. I and Part 1 of Vol. II, see Part 1, pp. 1303 to 1320)

Burnham scale for teachers' salaries (British), 243
Business, needs of, 52
  graduates in, 71, 109

California, data on employment, 59
California Polytechnic Institute, 40
Carnegie Corporation, funds from, v, 3
Carnegie Institute of Technology, 37, 40
  job analysis (printing), 127
Census data, U S, 74
Catholic schools in Paris, 204
Center of manufactures and of population (map), 46
Certificates, national (British), 231–234
  courses for, 234–240
Chalmers Institute at Gothenberg, 270
Chalons, 211
Chemical courses, 40–45
Chemical engineering graduates, 111, 112
Chemical industry, 64, 66, 68
Chemistry, school at Mulhouse, 204
Chicago, downtown college at, 140
Chicago Technical college, 140
  ages of students, 146
  building and construction, 171
  civil and structural engineering, 172
  drop-outs, 161, 162
  fees and costs, 187
  graduates, views of, 193, 194
  objectives of freshmen, 89
  opinions of directors, 194–198
  student work schedules, 165
  teaching methods, 160
Cincinnati, University of, cooperative plan, origin of, 182
  connections well-established, 186
  "loosely-coupled" programs, 185
City and Guilds of London Institute, certificates, 233
Civil and Structural courses, 40, 43, 172
Civil engineering courses, 44, 45
Clerical occupations, 79
Cleveland Y M C A school, 43, 139, 140
  ages of students, 146
  fees and costs, 188
  graduates, views of, 193, 194
  opinions of directors, 194–198
  student work schedules, 165
  subjects taught, 160
  teaching methods, 159
Cluny, school at (1891), 211
Coal industry, 75, 76, 264
College, see engineering college
College degree, absence of, 108, 109
College men in industry, 64–70
  (British), 213
Colleges, local technical (Great Britain), 212
Colleges, relation to technical institute, 21, 22, 26, 159, 160
Columbia, school of mines at, 35
Commercial field, curriculum, 106
Communication, employment in, 77
Compiégne, visit of Napoleon, 211
Computation course, 41
Concours of admission (French), 205, 206, 211
Concrete engineering course, 45
Construction courses, 40–44, 171
  European, 204, 236, 262
Continuing education, need and facilities for, 99–106, 194
Continuing schools (Scotch), 216
  (German), 247, 248
Contracting course, 40
Cooperative plan, 10
  course, mechanical, 190, 191
  half-time day courses, 42
  institutes, data, 138
  part-time plans (xiii—G), 182–187
Cooperative students appear in demand, 51
Cooper Union, 37, 39
Coordination of scholastic and industrial phases, 185
Cornell, 35
Correspondence courses, 45, 100, 101
Costs and fees, 187–189
  in cooperation plan, 184
  Germany, 267
  Great Britain, 241
Cotton manufacture, courses, 40–42, 166
Courses, see Curricula
Coventry, part-time day students at, 241

(For Index to Vol. I and Part 1 of Vol. II, see Part 1, pp. 1303 to 1320)

Craft subjects (Great Britain), 227
Credentials for non-degree courses, 34, 230
Curricula (xii—F), 166–184
  correspondence courses, 45
  courses, types of, 4
  day courses, 40–45
  evening courses, 43–45
  German, 257–265
  British, 215, 234–240
Curriculum building, aids in (x—Part VI), 126, 136
Czechoslovakia, schools in, 200

Dartmouth, 34
Datsch (xv—D), 250, 252, 254, 269
  activities, chart of, 251
Day courses, 40–42, 166–176
  enrollments possible, 9
Degree, college, effect of absence of, 108–109
  attitude of graduates, 193
  attitude of employers, 192
  other credentials (British), 14, 230
  University of London, 223, 234, 242
Design, courses, 41–45
Detroit, evening division at, 140
Deutschen Ausschus für Technische Schulwesen, 250 (see Datsch)
Diplomas (British), 231, 234
Diplom-ingenieur, 252
Domestic and personal service, 79
Doubs, school at, 205
Drafting, course, 41, 42
Drexel Institute, 22, 37, 43, 81
  electrical course, 178
Drop-outs, 161, 162
Dunwoodie Industrial Institute, 41, 140
Dyeing course, 40

Earnings of graduates, 99, 113, 114
  of students, 95, 96
  of students in cooperative plan, 184
  of teachers, supplementary, 155, 156
Eaton, Amos at Rensselaer, 32, 33
Ecole Brequet, 204
Ecole Centrale, 34, 202, 204
Ecole Centrale Lyonnaise, 202
Ecoles d'Arts et Metiers (xiv—B), 35, 205–212
Ecole Polytechnique, 34, 202
Ecole primaire, 202
Ecole Speciale das Travaux Publics, 205
Ecole Turgot, 204
Edinburgh, 217, 223
Education, continuing facilities for, 99–105, 194
  for adolescents (English), 214
  general objectives defined, 18
  preparatory, 145
  primary and vocational (French), 203
  secondary, relation to, 18
Education, technical, higher (Great Britain), 212, 213
Einjahriger, 249
Electrical engineering courses, 41–45, 175–180, 258
  apprenticeship (British), 219, 220
  certificates and diplomas, 231–236
  graduates, positions, 72, 111–114
    in communication and transportation, 77
Electrical manufacturing, 64–68
Employability of graduates without degrees, 109
Employers, advice to students, 92, 93
  attitude on degree issue, 192
  influence in placement, 189
  opinions regarding graduates, 120, 121
  views on need of trained men, 52–59
Employment managers, data from, 59
Employment, fields for (ix—D), 71–87
  paths of progression in, 115
  shifting of graduates in, 118, 119
Engineering courses, 40, 45, 181
England, local institutions (xiv—C), 212–246
Engineering colleges, early, 33, 34
  entrance into from technical institutes, 102
  industrial needs, 7

  experiences with cooperation plan, 183
  text books, 158
Engineering, school of, technical institute as, 22–24
England (xiv—C), 212–246
English, instruction in, 106
Erie Branch School, Pennsylvania State College, 178, 179
Essen, *maschinenbauschule* at, 256, 258, 260
Esslingen, *maschinenbauschule* at, 258
  for fine mechanisms, 259
  research institute, 267
Eta Kappa Nu Association, 113
Europe, technical institutes (xiii—Part VIII), 199–271
  general observations, 267
Evening courses, 43–45
  at day technical institutes, 10
  diploma school, Drexel Institute, 43, 81
Evening Instruction (British), 224, 234–236
  enrollment (England and Wales), 224
  limitations, 214
  London County Council, 230
  major and minor courses, 226, 227
  Scotland, 216
  textile manufacture, 237, 238
  value and characteristics, 240
Evening technical institutes, 139
Examination agencies (British), 230
Examinations (British) of apprentices, 220, 221
  for diplomas and certificates, 231–233
Expense at school, see fees
Extension schools, 139

Faraday House, London, 222
Fees and costs, 96, 187–189
  British schools, 241
  German schools, 267
Financial aspects of cooperative plan, 184
Financial, self-support, 96
Fitters, course for, 236
Flint Junior College, 181, 182
Foremen, courses for, 67, 205, 265
  responsibilities of, 127–136
Forestry, employment in, 74
Forging, 106
Fortbildungschule, 248
Foundry courses, 42, 106, 170, 236
France (xiv—B), 201–211
  provincial universities, 22
Franklin Institute, 30
Franklin Union, Boston, 41, 43
French language in British school, 218
Functional courses, 4
Functions of technical institute (vii—Part II), 16–27

Gardiner (Maine) Lyceum (1822), 31
Gas engineering, 231, 238
General Electric Company, 185
General Motors Institute of Technology, 43, 183, 184
Geographical field of technical institutes, 11
Germany, industrial schools (xv—D), 199, 200
Gewerbeschulen, 250
Girls, trade courses for (France), 203
Glasgow, Royal Technical College at, 254, 257, 258
  Sandwich Plan originated in 221
  University, 217, 223
    fees at, 242
Gothenberg, Chalmers Institute at, 270
Grading, 160–163
Graduates (ix—D), (ix—Part V), (xiii—I)
  adaptability, 8, 120, 121
  demand for, 51
    ratio to College men, 53, 55, 58
  earnings of, 113, 114
  employment, fields for (viii—Part IV), (ix—D), 71–87
  further education, 99–105, 193
  influence of, 192
  non-degree, credentials of, 233
  placement of, 189
  positions, types of, 109–123
Great Britain (xiv—C), 212–246
  contrasts, 28
  general observations, 199
Grenoble, 205
Gymnasium, 249

Hale, Benjamin, 31

(*For Index to Vol. I and Part 1 of Vol. II, see Part 1, pp. 1303 to 1320*)

Hamburg, 248, 257, 267
Halifax, technical college at, 234, 235, 241
Harnosand, school at, 270
Harvard, 34
Heald Technical School, 41
Heriot-Watt College, 217
High School vs technical institute, 19
High school graduates in technical institutes, 145
Highway courses, 41
Historical development of technical institutes (viii—Part III), 28–47
Hochbau, 262
Hochschulen, 250
Höhere bauschule at Stuttgart, 263
Höhere Maschinenbauschule, 254
  at Esslingen, 259
  at Hamburg, 257, 258
Horology, course, 40
Hotel business, 79
Huddersfield, technical college at, 225, 226
Huxley's "Educational Ladder," 217
Hydraulic engineering at Stuttgart, 263

Imperial College of Science and Technology, 233
Idaho, University of, 41
Industrial Arts, school of, 190, 191
Industrial engineering courses, 44, 45
Industrial experience of students, 147
  of teachers, 151
  substitute for shop work, 184
Industrial requirements of New Jersey, 52–63
Industrial technology, courses in, 166–172
"Industries are our laboratories," 184
Industries employing graduates, 64–87
Industries, specific, training for, 13, 24–25
Industry, graduates in, status of (x—B), 109–123
  need for trained men (viii—Part IV), 48–87
  positions, analysis of (x—Part VI), 127–136
"Industry Specifies its School Training Needs," by V. M. Palmer, 190
Ingénieur d'Arts et Métiers, 204, 212
Institute, see Technical Institute
Institution of Mechanical Engineers, 235
International Correspondence Schools, 45, 141
Iowa State College, 41

Job analysis for curriculum, 127, 136
  at Rochester, 127, 136, 190
Job, description of, 190
Junior College, character of, 9
  relation to Technical Institute, 20
  typical course in, 166
Junior technical school (British), 213–218

Knitting course, 42

Laboratories, in *baugewerkschulen*, 261
  in machine schools, 255
  in mechanical schools, 256, 257
Laboratory, need for in cooperative plan, 185
Land-grant colleges, 29
  course in industrial arts, 37
Laundering, course in, 168
Laundry Owners' Association, 79
Lewis Institute, 37
Liancourt (French), 210
Lille, 211
Lincoln (England), 225, 227
Lincoln Institute, Boston, 140
"Livery companies," 233
Loan fund, by alumni, 192
London, county area, enrollment in, 214
  Borough Polytechnic Institute, 235
  Faraday House, 222
  junior technical schools, 217
  Imperial College of Science and Technology, 233
  Northampton Polytechnic, 222
  polytechnics, 223, 242
  University of, 222, 242, 234
London County Council, 223
  School of Building, 225, 229, 230
  structural engineering, 239

(*For Index to Vol. I and Part 1 of Vol. II, see Part 1, pp. 1303 to 1320*)

Loughborough College, 222, 234
Lowell Institute School, 22, 39, 141
  courses at, 43
  description, 141
  fees, 149, 188
Lowell Textile Institute, courses at, 41
  description, 142
  objectives of freshmen, 89, 90
  student self-support, 96
  work of graduates, 115
Lycées, secondary schools, 201, 202, 204

Machine shop course, 40, 106
Machinists, course for, 236
Malmo, school at, 270
Managerial ability of graduates, 99
Managers in extraction of minerals, 75
Manchester Municipal College of Technology, 223, 225, 228, 234
Manuals, teaching, used, 158
Manufacture, analysis of for technical men, 85–87
Manufacturing, employment in, 80–87
  geographical center, 46
  in Philadelphia, 82
Mapping, course, 41
Maryland Institute, Baltimore, 30
Maschinenbauschule at Essen, 256
Maschinenbauschulen, 250, 253, 254, 260
  curricula, examples of, 257–260
Mass teaching (France), 205
Massachusetts Institute of Technology, 35, 185
  Lowell Institute School at, 22, 39, 43, 141
  programs, 185
Massachusetts State Division of University Extension, 45, 180
Materials of teaching, 158
Mathematics, higher, 106
  course in (French), 203, 207
  curricula of (British), 215, 217, 218
  in machine schools (German), 255
Mathematiques speciales, 202
Mechanical courses, 41–43
Mechanical engineering courses, 41–45, 257
  diplomas and certificates (British), 231–235
  part time course in, 239, 240
  positions of graduates, 111, 112
Mechanical industries, 80
Mechanical schools, middle, 256
Mechanics course, 40
Mechanics' institutes (1820), 29, 30
Mechanics Institution of Glasgow (1823), 30
  of London (1824), 30
Metallurgical engineering course, 237
Metal trades, 40, 64, 66, 68
Methods of teaching, 159
Michigan, University of, 35
Michigan State College, 37
Military service (German), 249
Mine foremen, school for, 205
  curricula for, 265
Minerals, extraction of, employment in, 74–77
Mining engineering course, 45
Mining schools (German), 264
Ministry of Commerce and Industry, 250
Ministry of Education (French), 210
  (German), 256
Minnesota, University of, 45
Morrill Act of 1862, 24, 34
Motor car body builders, course, 236
Milwaukee School of Engineering, 41, 142
  age of students, 146
  graduates, views of, 193, 194
  opinions of directors as to technical institutes, 194–198
  school year, 165
  subjects taught, 160
  teaching methods, 159
Morris, J. T., ii, v
Mulhouse, 204

Napoleon, address on education, 211
National Educational Association, 18
National Industrial Conference Board, 3, 64, 73
New Jersey, industrial requirements of, 52–63

(For Index to Vol. I and Part 1 of Vol. II, see Part 1, pp. 1303 to 1320)

Newark (N. J.) Technical School, 22, 39, 57
  age of students, 146
  drop outs, 161, 162
  electrical course, 177
  evening courses at, 44, 139
  fees and costs, 188
  graduates, views of, 193, 194
  opinions of directors, 194–198
  special features, 164
  student work schedules, typical, 165
  teaching methods, 159
New Bedford Textile School, 42, 142
  age of students, 146
  fees and costs, 187
  graduates, views of, 193, 194
  junior college course, 166
  opinions of directors, 195–198
  student work schedules, 165
New Haven College, courses at, 40, 44
New Jersey, industrial requirements, 52–60
Nomenclature of post-secondary schools, 3
  European vs. American, 3, 4
  key term "technical institute," 4
Norrköping, school at, 270
Northampton Polytechnic, London, 222, 223

Oberrealschule, 249
Obersecunda, grade of, 249, 254, 261, 264
Objectives of graduates, 88, 89
Occupations, gainful, 1920–1925 (graph), 73
Occupations as related to courses, 115
Ohio Mechanics Institute, 142
  ages of students, 146
  courses, 42, 138, 167
  drop-outs, 162
  fees and costs, 187
  graduates, views of, 193, 194
  name, 16
  opinions of directors, 194–198
  power laundry course, 167, 183, 190
  school year, 165
  scope and methods, 30, 38
  student work schedules, 165
  teaching methods, 159
"Omnibus" type of education, 28
Omission of curricular subjects, 105
One year unit courses, 198
Orebro, school at, 270
Oregon Agricultural College, 37
Oxford, summer school at, 244

Palmer, V. M., paper by, 190
Paper and pulp industry, 64, 66, 68
Paper technology, at Grenoble, 205
Parents as advisers, 91
Paris, schools in, 203–211
Part-time courses (British), 227, 234–241
Pattern-making, 106
Paying way, see Self support
Pennsylvania State College, Extension Division, 44, 138, 143
  fees and costs, 188
  graduates, views of, 193, 194
  mechanical course, 178
  opinions of directors, 194–198
  school year, 165
  student work schedule, 165
  subjects taught, 160
  teaching methods, 159, 160
Pension, 202
Philadelphia, manufacturing in, 82
Philadelphia Textile School, 42, 81
Placement activities, 189
Polytechnic Institute of Brooklyn, 37
Post-graduation education, 99–106, 194
Post-secondary technical needs, 1
Power plant practice, course, 42, 170
Pratt, Charles, 38
Pratt, Frederick B., 3
Pratt Institute, 38, 54, 57
  ages of students, 146
  courses, 42, 138, 174, 175
  description of, 143
  drop-outs, 161, 162
  fees and costs, 187
  graduates, views of, 193, 194
    in industry, 69, 189
    occupations and courses, 115
  industrial mechanical engineering, 174
  industrial electrical engineering, 175

(*For Index to Vol. I and Part 1 of Vol. II, see Part 1, pp. 1303 to 1320*)

  name, 16
  objectives of freshmen, 89
  opinions of directors, 194–198
  preparation, 145
  subjects taught, 160
  student work schedules, 165
  teaching loads, 163
    materials, 158
    methods, 159
Preparatory education, 145
Printing course, 40
Production, trained men in (ix—C), 64–71
Professional service, employment in, 79
Professional standing of teachers, 157
"Professor," title of, 243
Public service, employment in, 78
Public Utility Companies, needs of, 57
Prussian Ministry, 260, 262

Railroad created demand for engineers, 33
  use of technical men, 77
Rating of graduates by superiors, 122
Realgymnasium, 249
Regent Street, 223
Rensselaer school, 29, 32–35
  established (1824) as school of science, 32, 33
  reorganized (1849) as polytechnic institute, 34
  technical profession fostered at, 35
Rensselaer, Stephen Van, 32
Research institutes (German), 267
Responsibilities, occupational, 124–136
Retail merchandising, 78
Reutlingen, textile school at, 265, 266
Richmond Mechanics Institute, 144
Rhode Island School of Design, 44, 143, 146
Robert Gordon College, 217
Rochester Athenaeum and Mechanics Institute, see Rochester Mechanics Institute
Rochester Chamber of Commerce, 190
Rochester Mechanics Institute, 38, 143
  ages of students, 146
  cooperative courses at, 42, 138, 183
  drop-outs, 161, 162
  fees and costs, 187
  graduates in management of institute, 193
    placement of, 189
    views of, 193, 194
  job analysis, 127, 136, 190
  name, 16
  opinions of directors, 194–198
  school year, 165
  survey of local industries, 190–192
  teaching materials, 160
    methods, 159
Rockwell, E. H., letter of, 54
Royal Naval College at Greenwich, 221
Royal Ordnance Factories, 221
Royal Society of Arts, 231
Royal Technical College, 217, 234, 237, 238
Rubber industry, 64, 66, 68
Rutgers University, Extension Division, 44, 138, 143
  ages of students, 146
  fees and costs, 188
  graduates, views of, 193, 194
  letter from dean, 54
  opinions of directors, 194–198
  school year, 165
  student work schedules, 165
  survey of New Jersey industries, 52–57

Salaries of teachers, 155
  British, 242–243
  German, 266
Salesmen, 78
"Sandwich Plan" (British), 182, 186, 221
Scandinavia, 267, 269
Schneider, Herman, Dr., 182, 183
Schofield, Dr., 222
Scholarships by alumni, 193
School-extension centers (map), 46
  School year, length of, 165
Science, more recommended, 106
  curricula of (British), 215, 217
Scottish educational system, 216, 242

Secondary education, relation to, 18
Secondary schools, growth, 34
Self-support at school, 95–97, 148–149
  extent of (graph), 149
  for young engineers (Great Britain), 214
Seminaristisch, 255
''Senior courses'' (British), 218, 224
Sheet metal workers, 236
Sheffield, University of, 221, 222
Shop practice (French), 208, 209
Shops vs laboratories, 184
Shop school, internal, 222
Silliman, Professor, of Yale, 32
Smith-Hughes Act, 16, 20
Society for the Promotion of Engineering Education, ii, v
Spahr, R. H., ii, v
Specialization in engineering courses, 23
  in technical functions, 25
  in technology of industries, 24
Specialized courses, graduates of, 63
''Specialized technical phases,'' 131
Spinning course, 42
Spring Garden Institute, 83
Standards and grading, 160–163
Steam and marine course, 45
Steiger courses, 264
Strasbourg, 204
Structural engineering courses, 40–45, 239
Students and student life (xi—B), 95, 144–150
Studienrat, 266
Stuttgart, 263, 266
Sulzer Brothers, 249
Summer school for teachers (British), 244
Summer vacations, 97
Supervision of student's work, 164
Supervisory forces in manufacture, 86
  positions and college men, 64–68, 99, 127
Surveying course, 41, 43
Sweden, number of schools in, 253
  technical education in, 200, 269, 270
Switzerland, typical schools in, 200
  technical education in, 270–271
  technical science in, 267
  technika, number of, 253

Teachers (xi—C), (xii—D E)
  advice on school attendance, 91
  British, 242–244
  German, 266–267
Teaching, loads and working schedules, 163–166
  Baugewerkschulen, in, 261–263
  direct, in junior schools, 218
  higher machine schools, 255
  university, professional, 255
Technical education, expansion of, at the college level, 35–36
  electrical engineering, in (British), 219
  in English system, 213
  expansion of, 7
  German, 247, 250–252
  higher (British), 212
  in United States, 269
  social and economic ends of, 268
Technical functions, training for specific, 25
Technical institutes of Europe (xiii—Part VIII), 199–271
  comparisons, 28, 199, 267–269
  France, 201–210
  Germany, 247–267
  Great Britain, 212–246
  Sweden, 269–270
  Switzerland, 270–271
Technical institutes, study of, 1
  conclusions, principal, 1, 5
    summary of, and introduction (vii—Part I), 1–15
  occasion for the study, 1
  name, 1, 4, 16
  scope and objects of study, 4
Technical institutes, successful, 38, 70
  character, distinctiveness, 9
  cooperative plan, 186
  development, opinions as to, 194–198
  fields, largest of, 13
  functions of (vii—Part II), 12, 16, 27
  graduates of, see graduates
  historical development of (viii—Part III), 28–47
  location of (map), 46
  possibilities in, 186

(*For Index to Vol. I and Part 1 of Vol. II, see Part 1, pp. 1303 to 1320*)

- relations of, with universities, 223
- as schools of engineering, 22
- solidarity, lack of among, 14
- status of (viii—Part III), 28
  - See Part 1, page 1319

Technical institute, as a going concern (xi—Part VII), 137–198
- community type, a plan for, 186
- conspectus, general, 137–144
- cooperative half time plans, 182–187
- costs, 187–189
- curricula, 166–182
- fees, 187–189
- influences of employers and alumni, 189–194
- methods of teaching, 157–163
- opinions as to development, 194–198
- students and student life, 144–150
- teachers, 150–157
- teaching loads and working schedules, 163–166

Technical positions and college men, 64, 66, 68
Technical training meets requirements, 98, 99
Technical schools, adaptation to local needs, 22, 223
- shifting into college group, 37

Technical science in Central Europe, 267
Technical training needs of industry (xiii—Part IV), 48–87
Technikum, 250, 270
Techniker, 252
Technikum fur Textilindustrie, 265, 266
Technische Erziehung, 252
Technological courses, 4
Technology of specific industries, training in, 24–25
Technology, meaning of, 24
Text-books, few used, 158
- use of, in France, 210

Textile courses, 41, 42, 44, 237, 238
Textile institutes, alumni, 72, 74, 81
Textile school, Reutlingen, 265, 266
Textile schools, men trained in, 84
Textile technology, Mulhouse, 204
Text material of assignments, 164
''Theoretical'' courses, 102, 103
Thompson, C. O., 36
Three-year program (France), 207, 208
Tiefbau, 262
Time plans compared, 197
Tool design course, 42
Toolmakers, course for, 236
Topography course, 41
Toulouse, 205
Trade, employment in, 78
Trade courses in high school, 19
Trained men, number needed, 195
Training possessed by men in industry, 65
Training, requisite length of, 23
Transportation, employment in, 77
Turner, Jonathan, philosophy of, 35

Union College, 34
U. S. Census, employment, 74
Universities and colleges, relation to technical institute, 21
- French, 207
- German, 247
- Great Britain, 212, 213, 223, 230, 242
- Scotch, 216

Verein Deutscher Ingenieure, 200, 250
Virginia Mechanics Institute, 45
Vocational courses in high schools, 19
Vocational education (French), 203
Vocational education, relation of technical institute to, 19–20
Volkschule, 247, 248, 254, 263

Wales, 218, 224, 232, 241
Washington University, 45
Wasserbau, 262
Welfare institutions and cooperative plan, 185
Wentworth Institute of Boston, 38, 54, 144
- ages of students, 146
- courses, 42, 138, 170
- description of, 144
- drop-outs, 161, 162
- fees and costs, 187

(*For Index to Vol. I and Part 1 of Vol. II, see Part 1, pp. 1303 to 1320*)

  foundry course, 170
  graduates, views of, 193
    occupations and courses, 115
  name, 16
  opinions of directors, 194–198
  power plant practice, 170
  preparation for, 145
  student work schedules, 165
  teaching loads, 165
    methods, 160
    subjects, 160
Westinghouse Technical Night School, 144
  ages of students, 146
  courses at, 45, 139
  drop-outs, 161, 162
  fees and costs, 188
  graduates, views of, 193, 194
    occupation and courses, 115
  objective of freshmen, 89
  opinions of directors, 194–198
  teaching methods, 160
  self-support of students, 96
  student work schedules, 165
Wickenden, W. E., Director, ii, v
Winterthur, Switzerland, 249, 271
Wisconsin, University of, 45
Wolverhampton Technical College, 236, 237, 241
Wool Manufacturing course, 41
Woolwich Polytechnic, 239–241
Worcester County Free Institute of Industrial Science, 36, 37
Worcester Polytechnic Institute, 37, 211, 212
Work of student under supervision, 164
Workshop production course, 236, 237
Works-school, 221

Yale, 34
Y M C A schools, see Cleveland, New Haven
  welfare organizations, 185

Zurich, 270